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TEMPO

KS-20501-L3A

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INSTRUCTION AND MAINTENANCE MANUAL FOR RETURN LOSS TEST SET KS20501-L3A

MANUFACTURED FOR AT & T
by
TEMPO INSTRUMENT INC.
87 MODULAR AVE
COMMACK N.Y. 11725
U.S.A.

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1.0 INTRODUCTION

1.1 Description

The KS-20501 L3A Return Loss Measuring Test Set is a compact, portable, AC powered instrument designed to aid in the testing of return echoes on both 2-wire and 4-wire telephone lines. These tests, performed at central offices, help in determining the level of speech echoes and potential singing and oscillating conditions.

1.2 Scope of Manual

This manual details the following subjects:

.Various modes of return loss measurements
.Operating Instructions
.Routine Maintenance
.Calibration
.Trouble shooting/minor repair
.Schematic diagrams
.Parts list

1.3 Specification Summary

Test Type:	Echo Return Loss (ERL) Singing Return Loss (SRL) Singing Return Loss, High Freq. (SRL HI) Single Frequency Return Loss (Via EXT OSC)
Configuration:	2-wire, 600 and 900 ohms 4-wire, 600 ohms Test Hybrid VFPB
External Oscillator Range:	200 Hz to 15 kHz
Impedances:	2-wire: 600 and 900 ohms 4-wire: 600 ohms EXT OSC Input: 600 ohms
Return Loss Range:	-10 dB to +40 dB
Accuracy:	±0.4 dB, all test types
Internal Bridge:	600 or 900 ohms in series with 2.16 microfarads.
Circuit Loss Compensation:	0dB: 0dB of receiver gain +0dB: 0dB to 10.8dB of receiver gain adjustable in 0.2dB steps +23dB: +23dB of fixed gain, plus variable 0 to 10.8dB gain as above.

Output Signal:	One of three weighted white noise types, or external oscillator.
Noise weighing Filters:	ERL: 560 to 1965Hz (-3dB Points) SRL: 260 to 500Hz (-3dB Points) SRL HI: 2200 to 3400Hz (-3dB Points)
Output Level:	2-wire: -6 dBm for 600 ohms (Ref. 600Ω) -7.8 dBm for 900 ohms (Ref. 900Ω) (-6 dBm Ref. 600Ω) 4-wire: -5.4 dBm for 600 ohms (Ref. 600Ω)
Longitudinal Balance:	100Hz : 70dB 3KHz : 55dB
Dielectric Strength:	600VDC any line input to chassis ground.
Transients:	No damage will occur by 105VRMS 20Hz ringing signal for 10 seconds on either the input or output.
Primary Power:	117 VAC ± 10%, 60Hz
Operating Temperature and Humidity:	0 to 50 C, 95% relative humidity

1.4 General Background Information

1.4.1 A Simplified block diagram of the KS-20501 L3A Return Loss Measuring Set is shown in Figure 1-1. The test set can be divided into two basic sections-Transmitter and Receiver.

1.4.2 The Transmitter section provides test signal and appropriate output network for the external network under test. Three of the four test signals, of random noise in character, are generated within the L3A Set. Each of these consists of the results of passing the wideband noise source signal of the Noise Generator through a bandpass filter whose characteristics are defined. (Refer to Section 1-5.) The fourth test signal is derived from an external oscillator, and is used for making point-by-point return loss versus frequency measurements. One of these four test signals is selected by the TEST TYPE switch.

1.4.3 The selected test signal is applied to the TRMT terminals via the 4-wire Output Network for 4-wire measurements. In 2-wire mode, the selected test signal is used to excite the Internal Bridge, and the "Unknown" arm of the bridge is connected to the TRMT terminals.

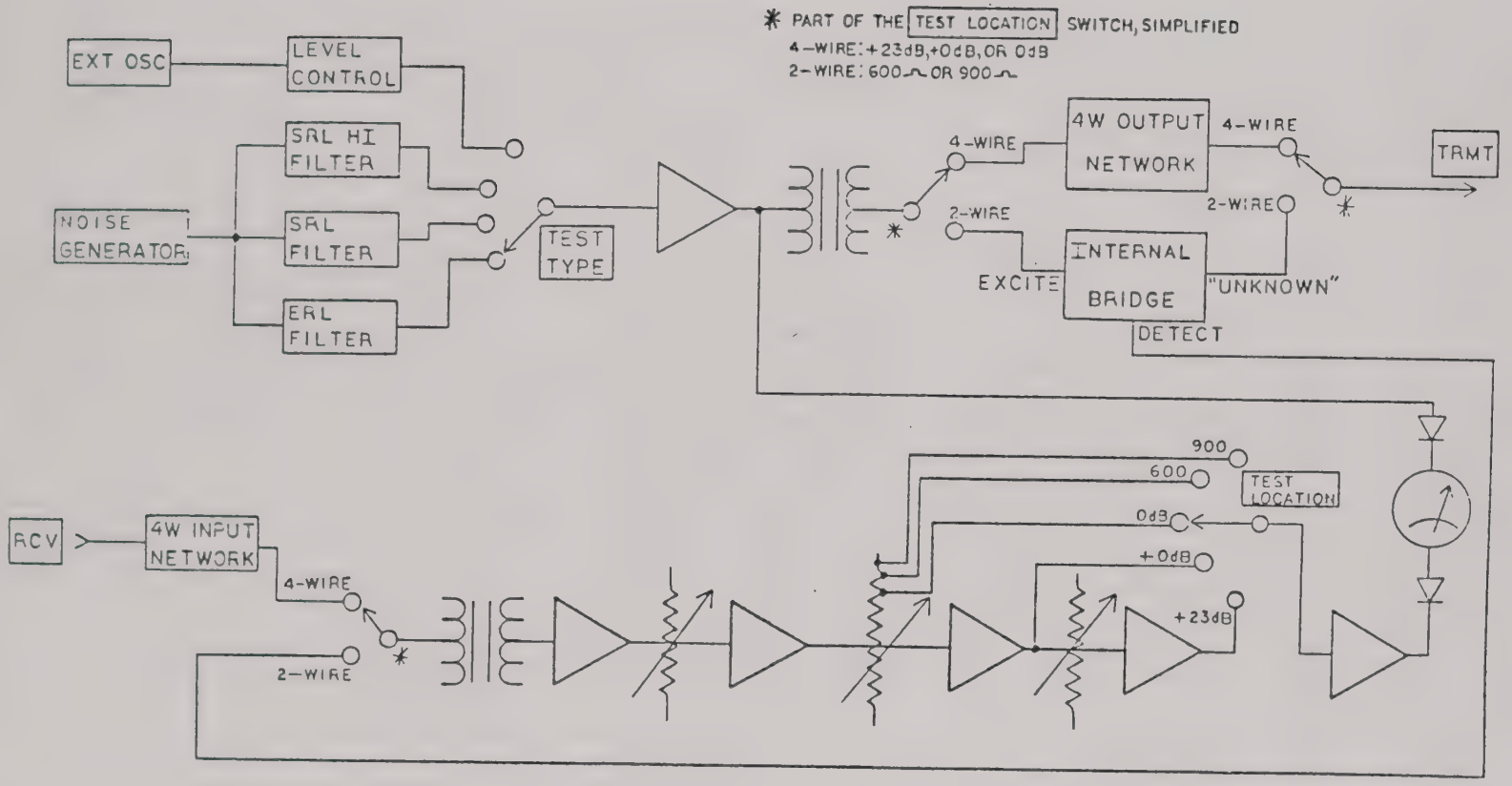


FIGURE 1-1 SIMPLIFIED L3A SET BLOCK DIAGRAM

1.4.3 (Cont'd)

When a 2-wire line, or an "unknown" network is connected across the TRMT terminals, it is being compared against the internal reference network of the bridge, and the return loss is measured by interpreting the voltage developed across the Detector terminals of the bridge as a result of such comparison.

1.4.4 The Receiver section consists of a number of voltage-gain stages and adjustable attenuators.

1.4.5 In the 4-wire mode, the return signal is applied to the Receiver section via the RCV terminals and the 4-wire Input Network. When the levels of the return signal and test signal are equal, or 0dB return loss, the output voltage of the receiver section is balanced out by the reference voltage derived from the Transmitter section for 0dB indication on the Return Loss dB Meter. If the return signal represents any loss, (or gain, for negative dB), then the attenuators may be adjusted for on-scale dB Meter indication. The return loss is equal to the dB Meter indication plus the attenuator settings.

1.4.6 In the 2-wire mode, the voltage developed across the Detector terminals of the Internal Bridge is applied to the input circuit of the Receiver section. The dB Meter indication is at the 0dB reference when the "Unknown" arm or the TRMT terminals are either shorted or opened. When a 2-wire trunk or network is connected across the TRMT terminals, the return loss measurement is a measure of its input impedance as compared with the internal reference network. The EXT NET terminals on the front panel provide for the use of an external network in place of, or in parallel with the internal reference network when the NETWORK switch is set to EXT or INT respectively.

1.5 Filter Curves

Three graphs that represent the standard filter curve characteristics are shown on pages 1-5, 1-6, and 1-7. These curves show relative attenuation in dB versus frequency in Hz for ERL (Echo Return Loss), SRL (Singing Return Loss), and SRL HI (Singing Return Loss High Frequency) filters.

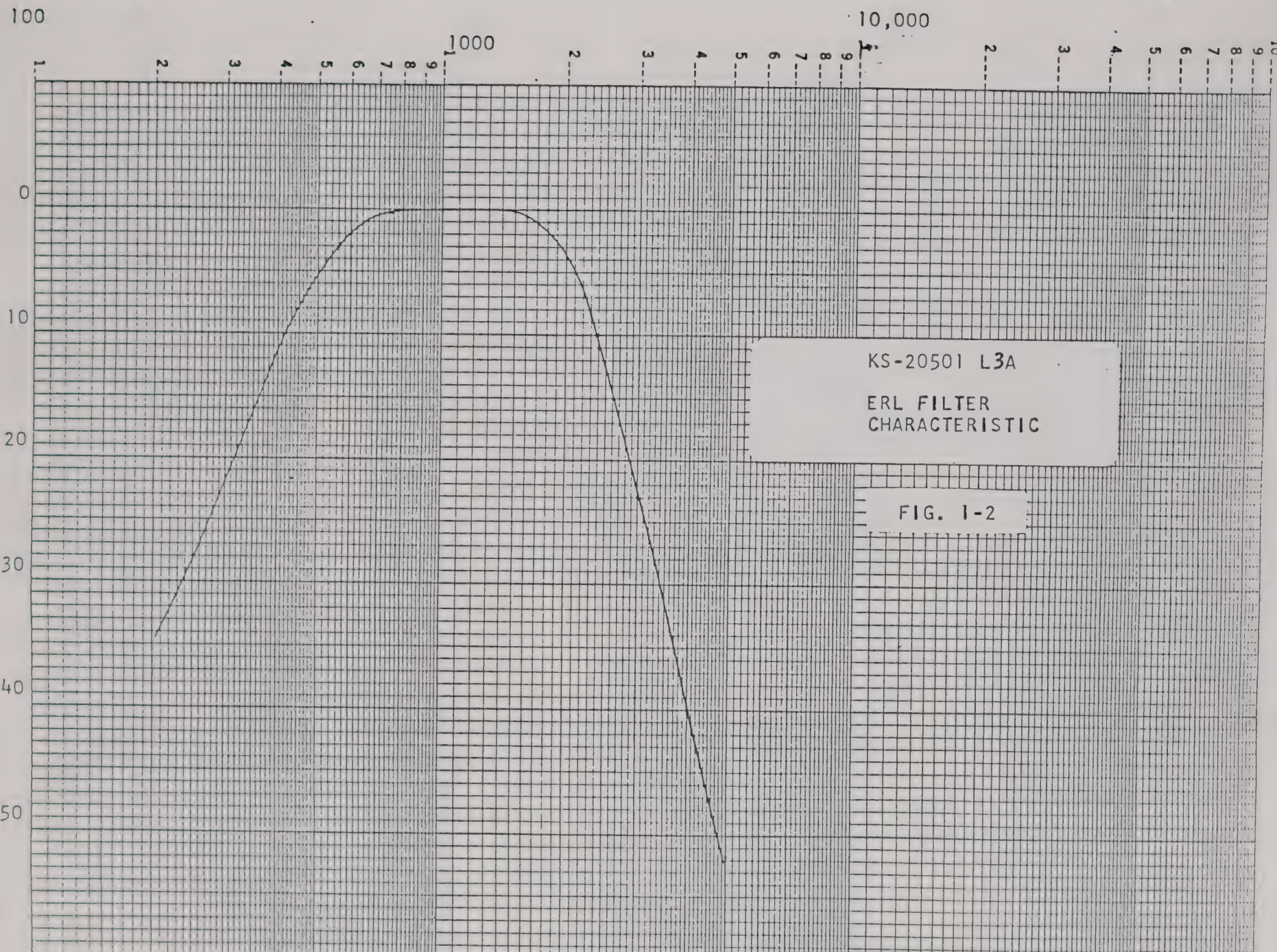

100
1000
10,000
0
10
20
30
40
50
KS-20501 L3A
ERL FILTER
CHARACTERISTIC

FIG. 1-2

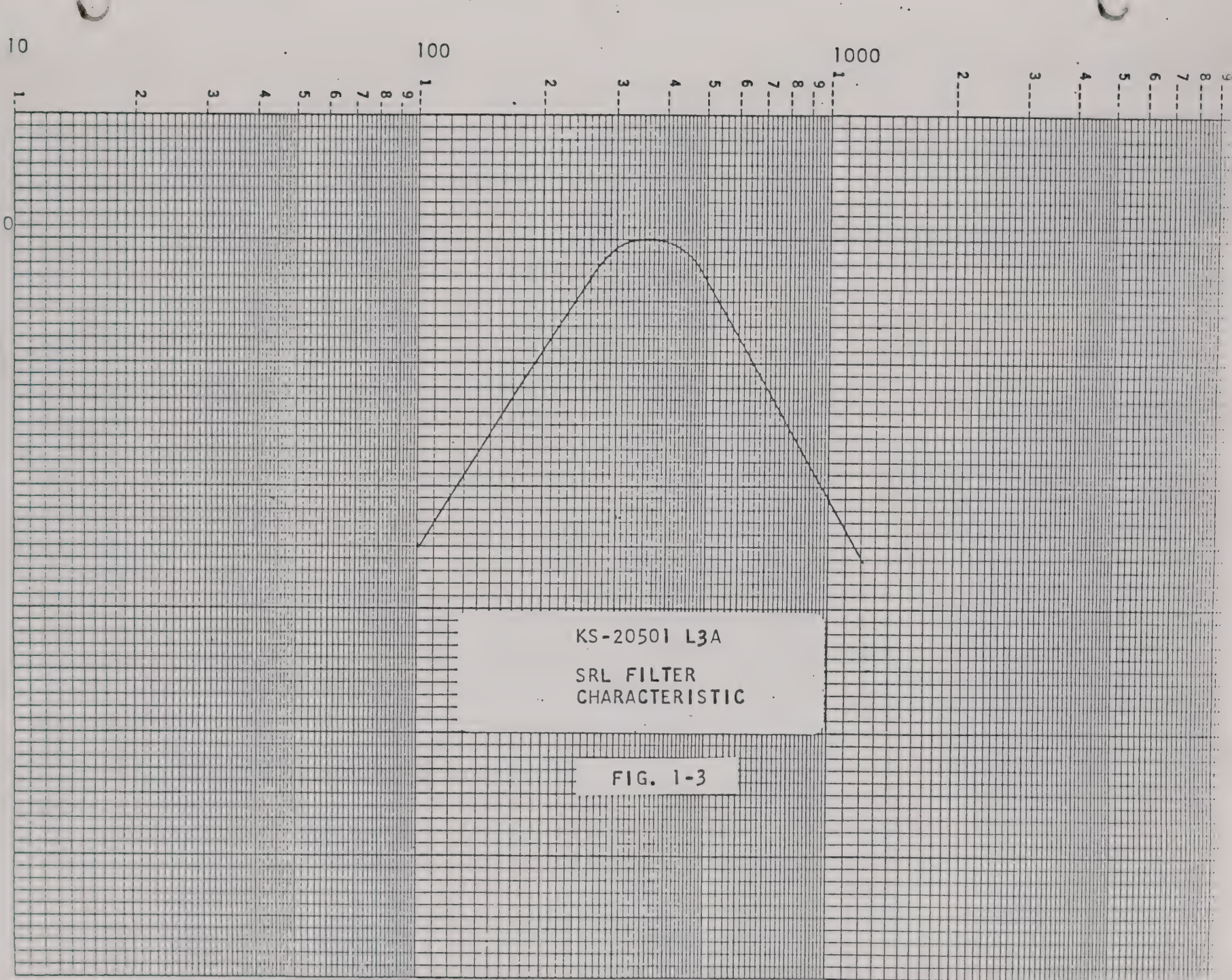

10
100
1000
0
10
20
30
40
50
KS-20501 L3A
SRL FILTER
CHARACTERISTIC

FIG. 1-3

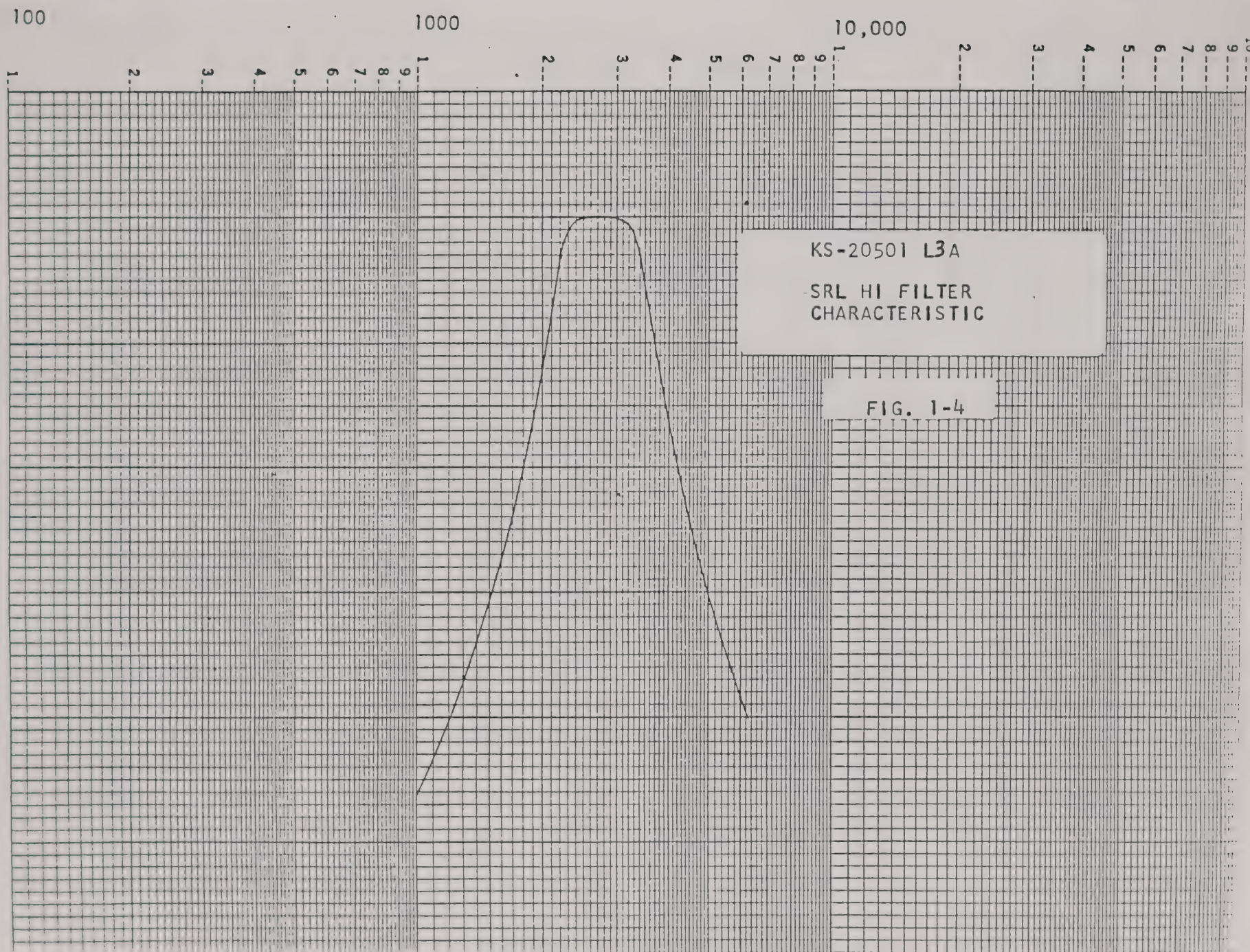

100
1000
10,000
0
10
20
30
40
50
KS-20501 L3A
SRL HI FILTER
CHARACTERISTIC

FIG. 1-4

2.0 OPERATING INSTRUCTIONS

2.1 Controls, Jacks, and Meter

2.1.1 PWR

The KS-20501 L3A set is powered from a nominal 117 volt, 60-Hz source. This ON/OFF switch is used to connect and disconnect power to the set.

2.1.2 TEST TYPE

This four-position switch allows selection of three internally generated signals or an externally connected oscillator test signal. The positions are designated ERL (Echo Return Loss), SRL (Singing Return Loss), SRL HI (Singing Return Loss High Frequency), and EXT OSC (External Oscillator). The output of these four test signals are maintained at a predetermined level set by the automatic gain control (AGC).

ERL - provides gaussian noise through a filter with 3dB bandwidth from 560 to 1965 Hz.

SRL - provides gaussian noise through a filter with 3dB bandwidth from 260 to 500 Hz.

SRL HI - provides gaussian noise through a filter with 3dB bandwidth from 2200 to 3400 Hz.

EXT OSC - Allows for the use of an external oscillator with the signal injected at the EXT OSC terminals. Any signal with a frequency of 200 Hz to 15 KHz may be used when measuring point-by-point return loss.

2.1.3 TEST LOCATION

This control is a five-position switch for selecting the sensitivity and measurement configuration of the set. The positions designated +23 dB, +0 dB, and 0 dB are for 4-wire measurements. The positions designated 600 and 900 are for 2-wire measurements.

+23 dB - provides a fixed gain of 23 dB plus an additional gain adjustable in 0.2 dB steps and up to 10.8 dB maximum using the two THL controls.

+0 dB - provides an adjustable gain in 0.2 dB steps and up to 10.8 maximum using the two THL controls.

0 dB - provides no adjustable gain. It is used when testing 4-wire circuits where no line loss compensation is necessary.

2.1.4 THL OR ADD

These two rotary switches are used to adjust the sensitivity of the set to allow for losses in the measured circuit, which should not be included in the return loss measurement. One is an eleven position rotary switch which is marked from 0 dB to 10 dB in 1 dB increments, and the second is a five position rotary switch marked from 0 dB to 0.8 dB in 0.2 dB increments. These two controls are used in conjunction with the TEST LOCATION CONTROL in the +0 dB and +23 dB positions; they have no effect in the 0 dB position.

2.1.5 ADD DB

This control is used to select suitable signal level to the detector circuit to maintain the meter on-scale. The five positions are designated -10, 0, +10, +20, +30, and when added to the dB Meter indication it results in the return loss measurement. Negative numbers indicate return gain.

2.1.6 NETWORK

This two-position switch provides selection between internal and external networks for 2-wire measurements. (Refer to Para. 3.2.5 for more details). The positions are designated INT and EXT.

2.1.7 TRMT

In the 4-wire mode these three jacks provide access to the output test signal. In the 2-wire mode these jacks are used to connect the line under test to the "unknown" arm of the internal bridge in the test set. One jack accepts a WECO 310-type plug and is designated 310. The other two are black binding posts being paired to accept a General Radio 938-type plug or its equivalent. All the jacks are electrically isolated from the front panel. One binding post is connected to the tip terminal of the 310 jack; the other is connected to the ring terminal of the 310 jack. The sleeve terminal of the TRMT jack is connected to the sleeve terminal of the RCV jack.

2.1.8 RCV

These three jacks are the same as the TRMT jacks, but they provide for the receiving of the test signal from a 4-wire connection only.

2.1.9 EXT OSC

These three jacks provide access for using an external oscillator in measuring point-by-point return loss.

2.1.9 (Cont'd)

One jack accepts a WECO 310-type plug and is designated 310, the other two are binding posts being paired to accept a General Radio 938-type plug or its equivalent. The black binding post is connected to the tip terminal of the 310 jack; the natural metal binding post is connected to the ring terminal of the 310 jack and chassis ground. These jacks are connected to the measuring portion of the set only when the TEST TYPE control is in the EXT OSC position.

2.1.10 EXT NET

These jacks provide for the use of an external network in place of or in parallel with, the internally provided one for 2-wire measurements. One jack accepts a WECO 310-type plug and is designated 310, the other two are black binding posts being paired to accept a General Radio 938-type plug or its equivalent. One binding post is connected to the tip terminal of the 310 jack; the other binding post is connected to the ring terminal of the 310 jack. These three jacks are electrically isolated from the front panel.

2.1.11 RETURN LOSS dB METER

This meter has a linear movement, with a logarithmic electrically expanded scale of 0 to 10 dB in 0.5 dB increments and indicates an increasing return loss with an up-scale reading. It measures the total return loss when used in conjunction with the ADD dB control.

2.2.0 OPERATING PROCEDURES

2.2.1 POWER AND SIGNAL CONNECTIONS

Connect the power cord to a nominal 117 volts, 60 Hz source. Turn ON the POWER switch when ready.

In the 2-wire mode, connect the 2-wire line or unknown network to the TRMT terminals.

In the 4-wire mode, connections for the output test signal and the returning signal are made to the TRMT and RCV terminals respectively.

If an external oscillator is used, connect the oscillator signal to the EXT OSC jacks properly. (The metal binding post and the ring of the 310 jack are connected to the chassis ground). The oscillator signal level should be set between -10 dBM and 0 dBm into 600 ohms, or between 0.25 and 0.775 Vrms into the EXT OSC terminals.

2.2.2 2-WIRE RETURN LOSS MEASUREMENTS

Refer to Para. 2.2.1 for power and signal connections.

Set the TEST LOCATION control to either the 600 or 900 2-wire position as required. Select the desired test signal using the TEST TYPE control. Set the NETWORK control to the INT position if the internal balancing network is to be used, or to the EXT position if a suitable external network is connected across the EXT NET terminals to replace the internal network.

Adjust the ADD dB control until the RETURN LOSS dB METER provides an on-scale indication. The indication of the RETURN LOSS meter in dB is added to the dB setting of the ADD dB control to give the total return loss.

2.2.3 4-WIRE RETURN LOSS MEASUREMENTS

Refer to Para. 2.2.1 for power and signal connections.

Set the TEST LOCATION control to the desired position. If the +23 dB or +0 dB is used, the known line loss correction should be inserted by adjusting the two THL controls. Select the desired test signal using the TEST TYPE control.

Adjust the ADD dB control until an on-scale indication is obtained on the RETURN LOSS dB meter. The return loss is read directly by adding the meter dB indication to the ADD dB control indication.

3.0 CIRCUIT DESCRIPTION

3.1 GENERAL

The L3A set can be divided into two basic elements: (i) the transmitter, and (ii) the receiver. A block diagram of the L3A set is shown in figure 3-1. The noise signal is derived by passing the output of a noise generator through either one of the three band pass filters. The output of an external oscillator may be connected across the EXT OSC terminals to provide the test signal for point-by-point measurement. One of these signals is selected, and its level is controlled by an AGC circuit to maintain a constant level at the TRMT terminals. Output networks are switch selectable for 2-wire and 4-wire measurements. The receiver is comprised of a number of fixed gain stages with interstage variable step attenuators to provide the required test set functions. The output of the receiver and the output of the transmitter are both fullwave rectified. The difference between these two rectified signals is displayed on the front panel meter. The following is a more detailed description of the test set circuits.

3.2 TRANSMITTER

3.2.1 NOISE SOURCE AND AGC

Figure 3-2 shows the circuit for the Noise Source and AGC. A noise generator board, designated as the "C" Board Assembly, is used to replace the noise generator U1 being used in the earlier version of the test set.

The noise generator on the "C" Board comprises U26, U27 and U28, as shown in Figure 3-2A. U26 is used as a 17-bit shift register with a single feedback tap at register number 12. The noise generator uses a maximal length sequence to generate a pseudo-random noise pattern whose spectral noise density is virtually flat to 10KHz. The output is connected to R188 where it is controlled by the AGC and is buffered via Q3 and Q4 to provide a low impedance output with optimal amplitude.

As the output of the noise generator is a square wave of pseudo random width, the desired AGC function is achieved by adjusting the amplitude of the square wave. It is performed by CR3, CR4, R188, R187 and R194 as follows: The output of the noise generator is a wave which ranges between about ground and slightly below V+. Resistors R188, R187 and R194 form a voltage divider. CR4 does not allow the signal to go much below ground. As the AGC input voltage decreases, the waveform at TP19 also tends to decrease in voltage, but it is clamped by CR3, thereby effectively decreases the pulse amplitude.

3.2.1 (Cont'd)

Figure 3-2B shows the AGC circuit when the output of an external oscillator is connected across the EXT OSC terminals as a signal source for point-by-point measurement. The P-Channel JFET Q6 is used as a voltage-controlled resistor which forms a voltage divider with R1 and C1. The drain-to-source resistance of Q6 decreases as the gate-to-source voltage decreases, and vice versa.

If the output level of Q6 is too high due to a large input signal, the AGC level is reduced in such a manner that when it is applied to the gate of Q6, the reduction of the drain-to-source resistance will cause the output level of Q6 to decrease until it reaches a pre-determined level. In a similar manner, the output level of Q6 is increased if it is lower than the pre-determined level.

3.2.2 BUFFER AMPLIFIER

The buffer amplifier is shown in Figure 3-3. The DC blocking capacitor C38 ensures that only AC signal is being amplified by the operational amplifier U18. This stage provides a gain of 23.9 dB for the frequency of interest and filters away undesired high-frequency noise.

3.2.3 FULL WAVE RECTIFIER AND LOW PASS FILTER

Figure 3-4 depicts the circuit for the Full Wave Rectifier and Low Pass Filter. The rectifier is made up of U19, U20, CR5 and CR6. The output of this rectifier is a positive going signal. Operation is as follows. When the input signal is positive, U19 output is negative, and CR6 conducts while CR5 is open. Due to the virtual AC ground at the input of U19, no signal is present at the positive input of U20. Therefore, with CR6 conducting, a negative input signal to the negative input of U20 produces a positive signal at the output of U20.

With a negative input signal (to U19), CR5 conducts while CR6 remains open. A positive signal (via CR5) is therefore applied to the positive input of U20, thereby again producing a positive output. As the negative input to U20 is not at AC virtual ground, some feedback to U19 will result via R161 and R163 which is accounted for in the rectifier's gain calculations.

The output of the fullwave rectifier is passed through a variable attenuator (R166) before being applied to the meter's summing amplifier. The rectifier's output is also applied to U21 which performs two functions. Via the feedback components (C45 and R168), U21 forms a high gain low pass filter which takes out the AC components at the rectifier's output. Also, via Z1 and R171, it compares the DC content of the rectifier output to the desired AGC threshold. U21 then outputs the proper level to adjust the AGC circuit so that the DC content of the full wave rectifier is equal to the voltage at the arm of R171.

3.2.4 OUTPUT NETWORKS

The output networks for 4-wire and 2-wire measurements are selected by the TEST LOCATION control, which is a 9-pole, 5-position switch. (S2A, B, C, D, E, F, G, H, and J). When the TEST LOCATION control is at +23 dB, +0dB, or 0dB position, as shown in Figure 3-5, the output network for 4-wire measurement is selected.

Resistor R178 provides impedance matching between the buffer amplifier and the output network. It is equal to 600 ohm less the resistive losses in the transformer T2. The transformer provides isolation and a balanced signal output. The "0" pad made up of R174, R175, R177, and R183 provides 5.3dB of attenuation and also provides a stable and accurate output impedance. Capacitors C32 and C33 provide the DC blocking required by the test set. V2 is a gap discharge tube which fires only when large DC voltages appear across the output lines.

When the TEST LOCATION control is at the 600 or 900 position, the output winding of T2 provides a selected type of test signal to excite an internal bridge. The detector terminals of the bridge are connected to the input transformer T1 of the receiver via R202 and R203. (Refer to Figure 3-1) Three of the four arms of the internal bridge are identical, each of them consists of a precision resistor in series with a 2.16uf $\pm$1% capacitor. The value of the resistor is either 600 ohms $\pm$0.1% or 900 ohms $\pm$0.25% depends on whether the TEST LOCATION control is at the 600 or 900 position respectivel When a 2-wire line or an unknown network is connected across the TRMT terminals, it is connected to the internal bridge as the fourth arm via two D.C. blocking capacitors C32 and C33. One of the three identical arms is used as the internal reference network which the 2-wire line under test or an unknown network compares with. Two back-to-back capacitor C75 and C76 are connected in series with the internal reference network (R209, R210, C71) at the same arm of the bridge to balance the series capacitors C32 and C33.

The impedance seen looking into terminals 3 and 4 of transforme T2 is 600 ohms; therefore, when the TEST LOCATION control is at the 900 ohms position, two 150-ohm resistors R204 and R205 are connected in series with terminals 3 and 4 of T2 to raise its output impedance to 900 ohms. The input impedance of the detector/receiver is treated in the same manner; two 150-ohm resistors R202 and R203 are connected in series with terminals 1 and 2 of the input transformer T1, raising the input impedance of the detector/receiver from 600 ohms to 900 ohms. (Refer to Figure 3-1).

3.2.4 (Cont'd)

The imbalance of the bridge is processed by the detector/receiver as a measure of the return loss of the 2-wire line or unknown network, and the result is indicated by the dB meter reading added to the total dB settings of the ADD dB control.

3.2.5 NETWORK CONTROL (Refer to Figure 3-5)

When the NETWORK control is at the INT position, the 2-wire line under test (or an unknown network) is compared against the internal reference network. With the TEST LOCATION control set to the 600 ohms position, the internal reference network is composed of a 600-ohm resistor R209 connected in series with a 2.16uf capacitor C71. With the TEST LOCATION control set to the 900 ohms position, a 300-ohm resistor R210 is connected in series with R209 to make up the required 900-ohm resistance.

Under certain circumstances, neither of the two internal reference networks are satisfactory for 2-wire return loss measurements. An external reference network can be connected across the EXT NET terminals to replace, or to parallel with, the internal reference network.

With the NETWORK control set to the EXT position, the 2-wire line or an "unknown" impedance at the TRMT terminals is now compared against the external reference network at the EXT NET terminals. Since the capacitors C75 and C76 in the reference arm of the bridge are used to balance the DC blocking capacitors C32 and C33 in the "unknown" arm, the "unknown" network and the external reference network should result in less than 0.4 dB change in SRL readings when they are interchanged.

3.2.6 FILTERS

The SRL HI filter is shown in figure 3-6. It is comprised of a cascade of three isolated single pole active filters. The filter gain at midband is +2.78dB. The center frequency is at 2700 Hz and the -3dB points are at 2200 Hz and 3400 Hz.

The SRL filter is shown in figure 3-7. The first two stages of the filter are isolated single pole active filters similar to above. To obtain the required shape at the high frequency end, they are followed by a two pole low pass filter. The active element for the low pass filter is a single transistor, since the requirements on this low pass filter are not too severe.

3.2.6 (Cont'd)

The ERL filter is the most complex filter, and is shown in figure 3-8. It is made up of five active elements, the first three being band pass filters similar to above. Again, in order to obtain the required high frequency response, a low pass filter was added to the output. The low pass filter represents a four pole which adds 22.75dB of attenuation at 5000Hz.

3.3 RECEIVER

3.3.1 RECEIVER INPUT CIRCUIT

The receiver input circuit is shown in Figure 3-9. Two of the nine poles in the TEST LOCATION control are used to select appropriate incoming signal to the input transformer T1 of the receiver. When the TEST LOCATION control is set to +23 dB, +0 dB, or 0 dB, these two poles (S2F and S2G) are connected to the input network for 4-wire measurements. Capacitors C30 and C31 provide the DC blocking as required by the test set. Resistors R75, R76, R77, and R78 form an "0" pad which provides 5.3 dB of attenuation and also provides a stable and accurate 600-ohm input impedance. C68 filters any high frequency signal from the input, and V1 is a gap discharge tube which fires only when large DC voltages appear across the input lines.

When the TEST LOCATION control is set to the 600 or 900 position, the primary winding of the input transformer T1 is connected across the detector terminals of the internal bridge for 2-wire measurements, and the receiver is used as the detector of the bridge. Since the impedance seen looking into the terminals 1 and 2 of T1 is 600 ohms, two 150-ohm resistors R202 and R203 are connected in series with these terminals to make up the required 900-ohm impedance when the TEST LOCATION control is set to the 900 position. The load to the transformer is divided into two equal resistors R79 and R80 so as to provide a balanced drive into the first amplifier. As in the transmitter, the value of the resistors reflect the resistive loss in the coupling transformer.

3.3.2 RECEIVER GAIN BLOCK

The receiver gain is provided by five gain stages. The receiver gain block is shown in figure 3-10. The signal flow is as follows. At the input, diodes CR1 and CR2 prevent input transients from overdriving the input to the first stage U14. The first stage provides 20dB of gain, and drives the 10dB step attenuator (ADD DB), the attenuator output S3 is connected to the high impedance positive input of the second gain stage U15.

3.3.2 (Cont'd)

The second stage provides 18.1dB of gain, and provides the output for the 900-ohm and 600-ohms of 2-wire measurements as well as the "0"dB" of 4-wire measurements. The second stage also drives the 1 dB step attenuator (THL or ADD). Since there are fixed amounts of level difference between the received signals, two resistors R196 and R197 are used to make appropriate level corrections so that return loss may be measured with no correction being necessary by the user. R197 makes 1.44 dB level correction between 600-ohm 2-wire and 600-ohm 4-wire measurements. R196 and R197 together make 4.96 dB level correction between 900-ohm 2-wire and 600-ohm 4-wire measurements.

The output of the 1-dB step attenuator drives the high impedance positive input of the third gain stage U16. The insignificant loading of U16 to the attenuator makes it unnecessary to set the attenuator to the 0dB position for 2-wire measurements. U16 provides 10.8 dB of gain which makes up for the loss in both THL OR ADD attenuators (1 dB step and 0.2 dB step) when the TEST LOCATION control is set to the +0 dB or +23 dB position. The output of this stage drives the 0.2 dB step attenuator. The combination of these two attenuators facilitates an adjustment of 10.8 dB in 0.2 dB steps.

The output of the 0.2 dB step attenuator provides the +0 dB receiver output; it also drives the fourth gain stage U17. U17 provides 23.0 dB of gain required when the TEST LOCATION control is set to the +23 dB (VFPB) position. The RC low pass filter at the input to U17 filters wide band noise, since the receiver is set at maximum gain. The last gain stage U22 is a 13.2 dB gain amplifier which drives the receiver's full-wave rectifier.

3.3.3 FULL-WAVE RECTIFIER (RECEIVER)

The full-wave rectifier of the receiver as shown in figure 3-11. It is basically the same as the transmitter's full-wave rectifier, except the diodes are inverted. This provides for a full-wave rectifier with a negative going output signal.

3.3.4 METER AMPLIFIER AND LOW PASS FILTER

The meter amplifier and low pass filter is shown in figure 3-12. The difference of both full-wave rectifiers is generated by R143 and R142. R144 and CR9 prevent the op-amp from swinging too positive, thereby limiting the meter drive in the negative direction. Capacitor C66 provides the low pass filtering required by the meter. This circuit provides almost full cancellation of meter fluctuations at 0dB indication due

3.3.4 (Cont'd)

to noise. This is due to the fact that the transmitter output is subtracted from the receiver input to generate the meter drive. When no return loss is present (0dB), the two signals are equal, regardless of transmitter power, thereby providing zero drive to the meter.

3.4 POWER SUPPLY

The power supply is shown in Figure 3-13. The center-tapped step-down transformer T3 receives its power from a 115V + 10% 60Hz AC outlet via fuse F1 and power ON/OFF switch S6. The rectifier bridge DB1 and capacitors C73 and C74 provide input power to VR1 and VR2, which are +12V and -12V regulators respectively. The output voltages are regulated over the specified range of line voltage variations.

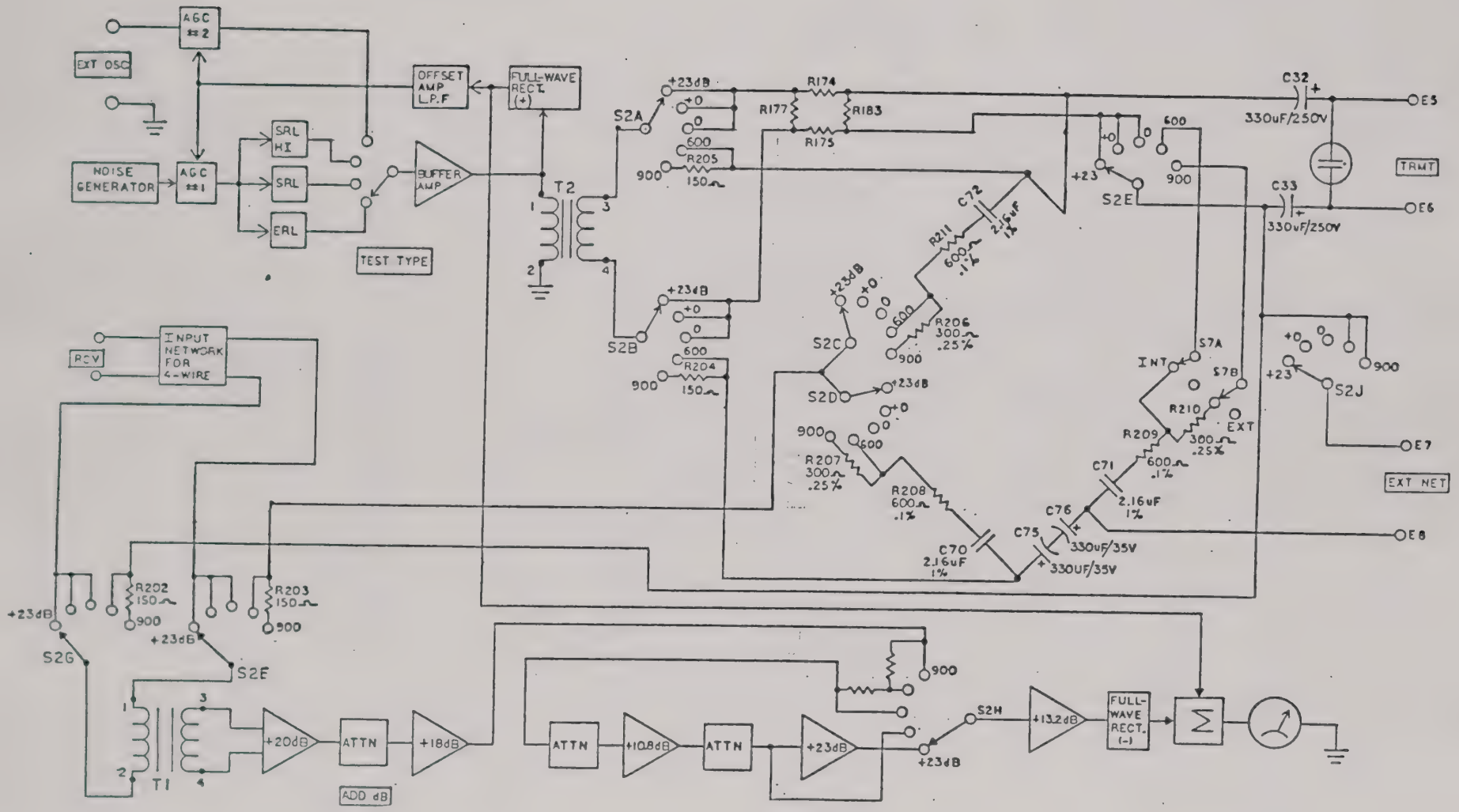


FIGURE 3-1
L3A TEST SET BLOCK DIAGRAM

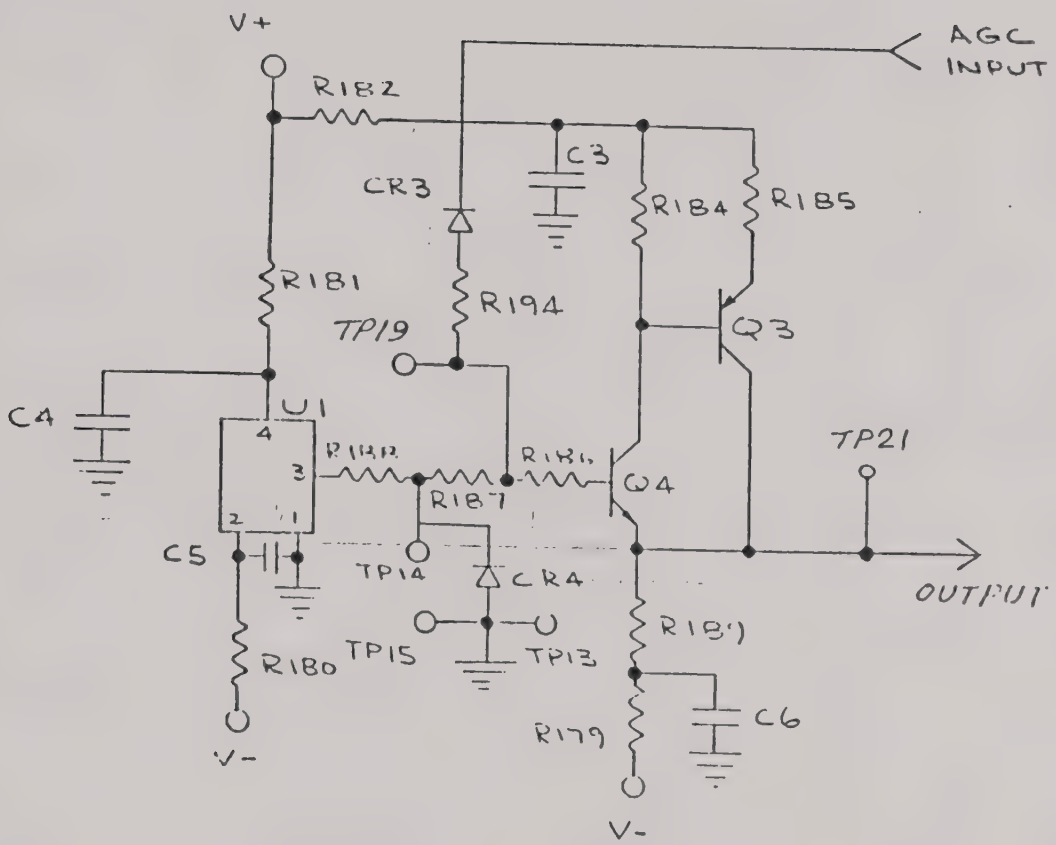


FIGURE 3-2 NOISE SOURCE AND AGC

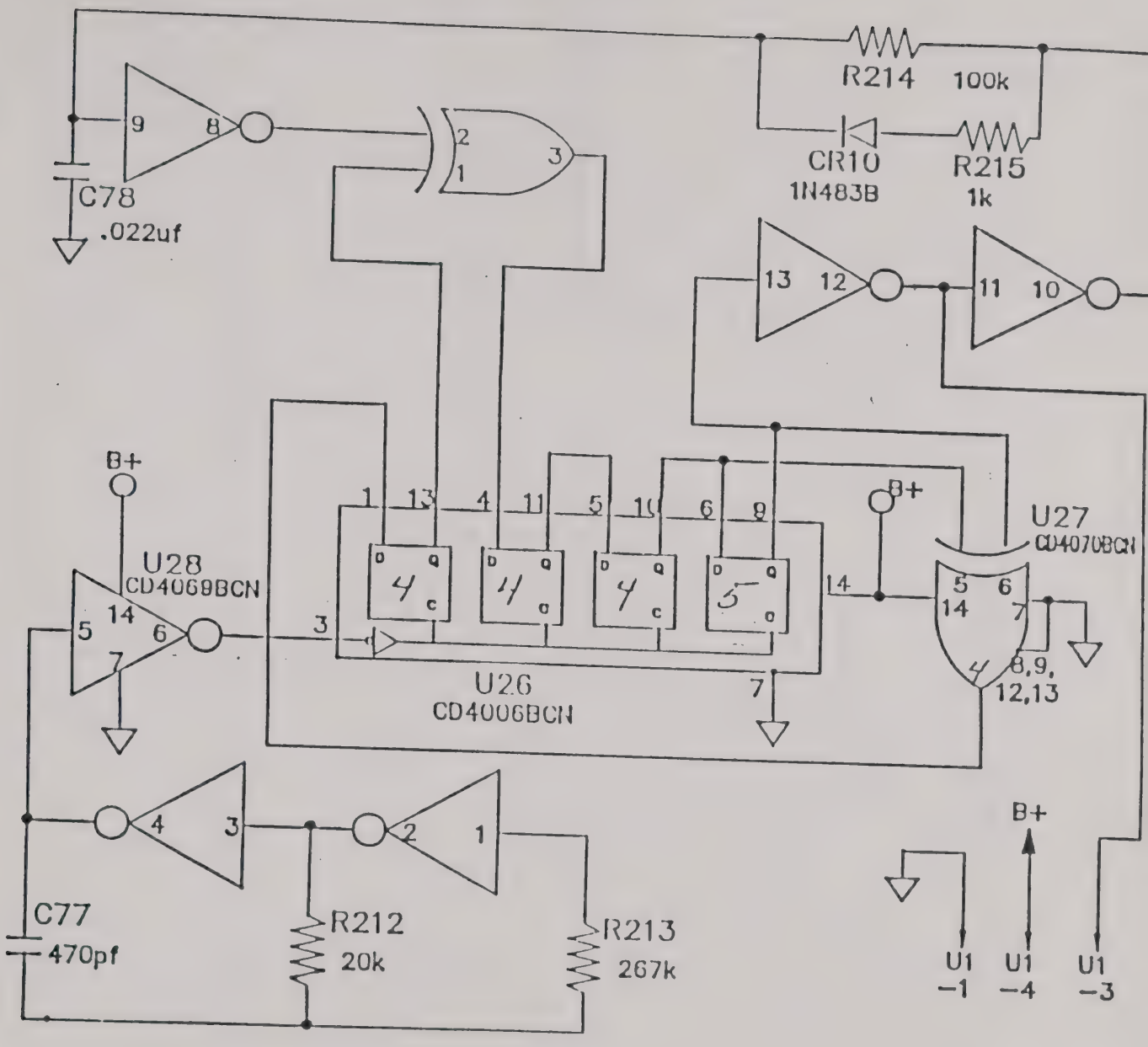


FIGURE 3-2A NOISE GENERATOR

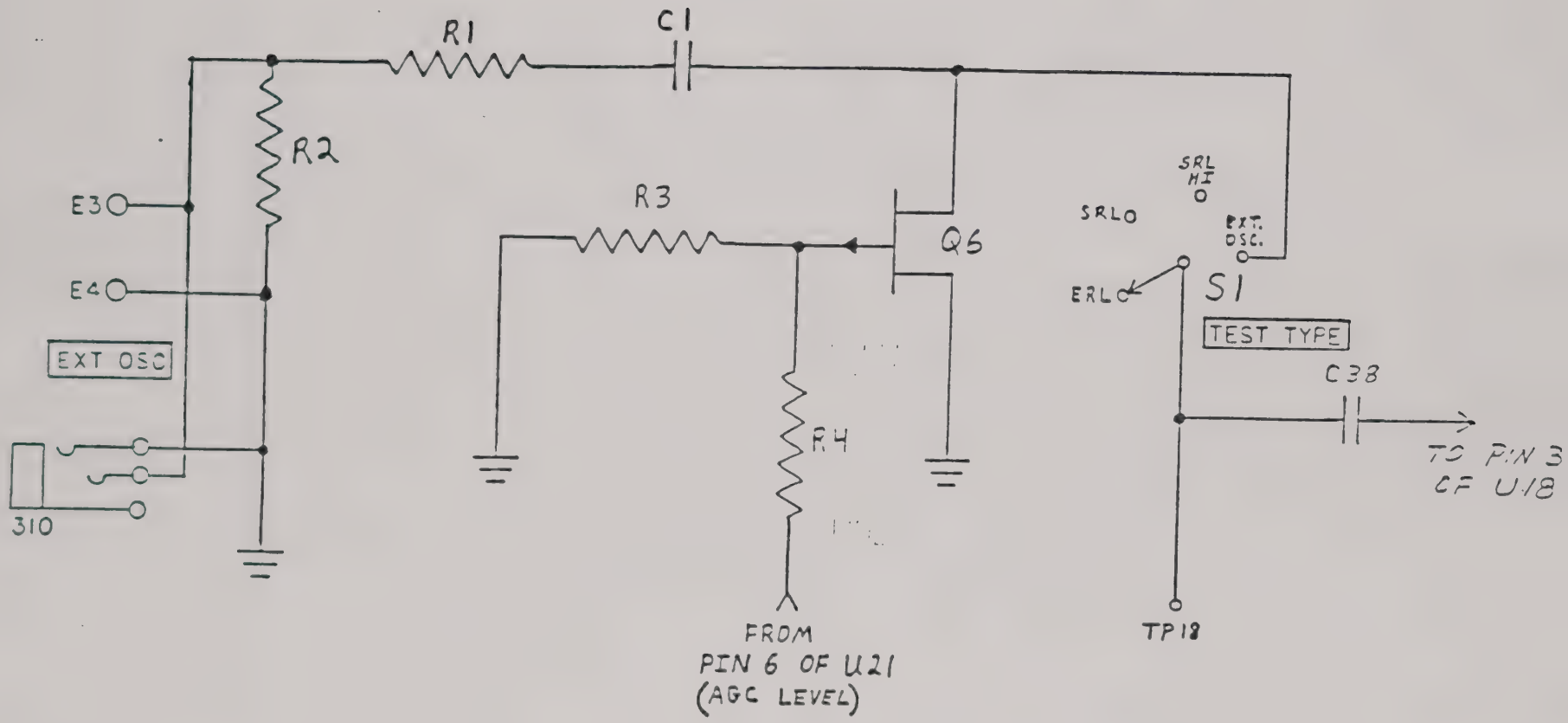


FIGURE 3-2B EXT OSC

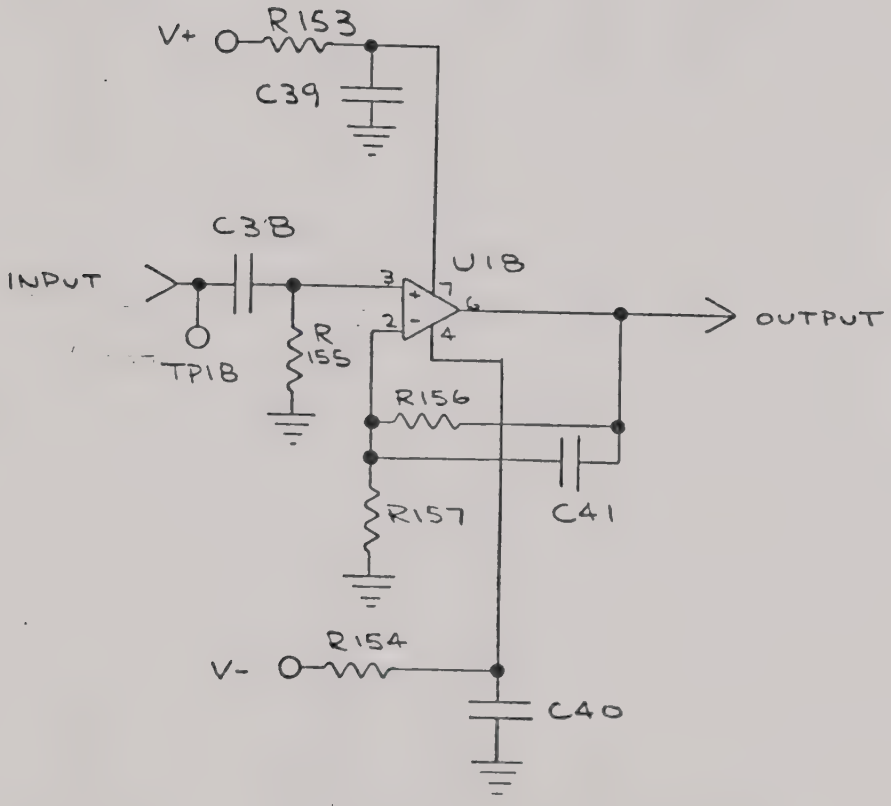


FIGURE 3-3 BUFFER AMPLIFIER

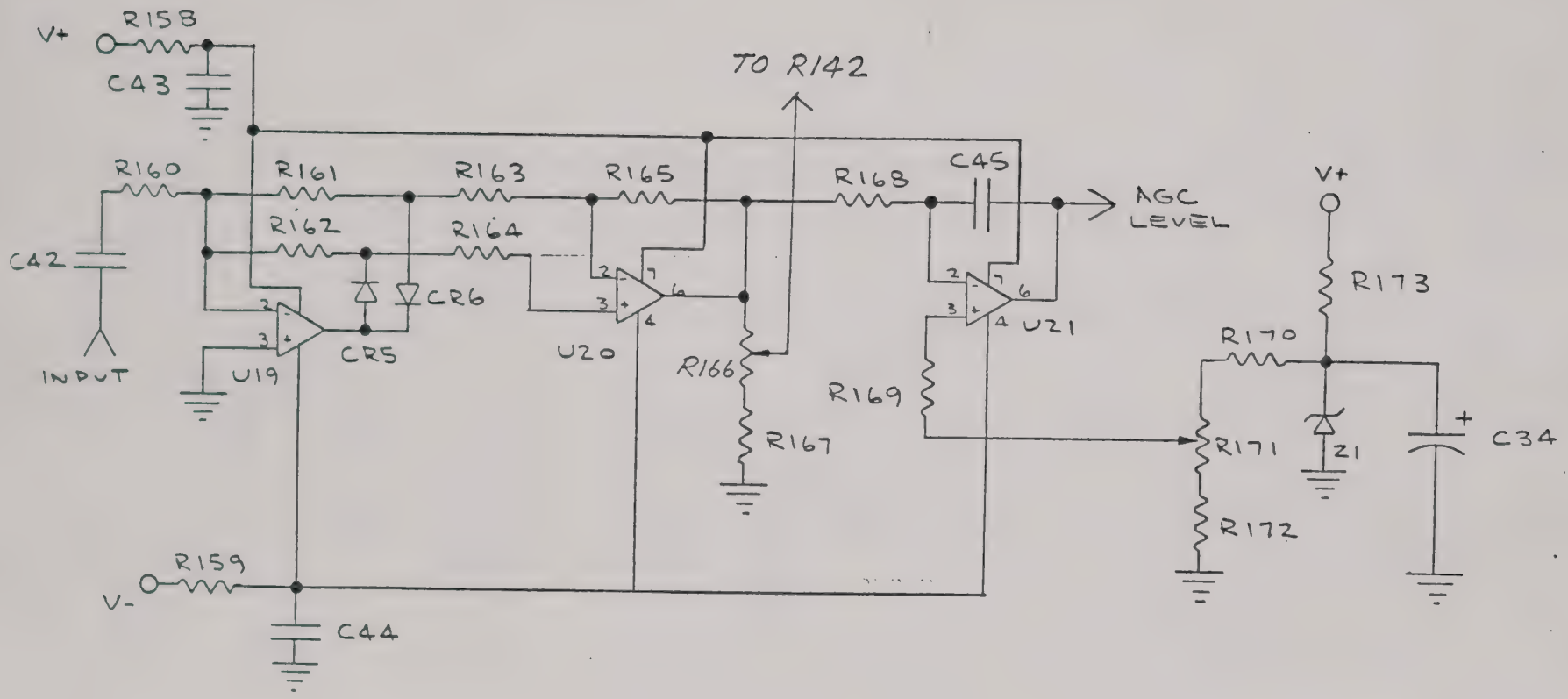


FIGURE 3-4 TRANSMITTER FULL-WAVE RECTIFIER AND LOW-PASS FILTER

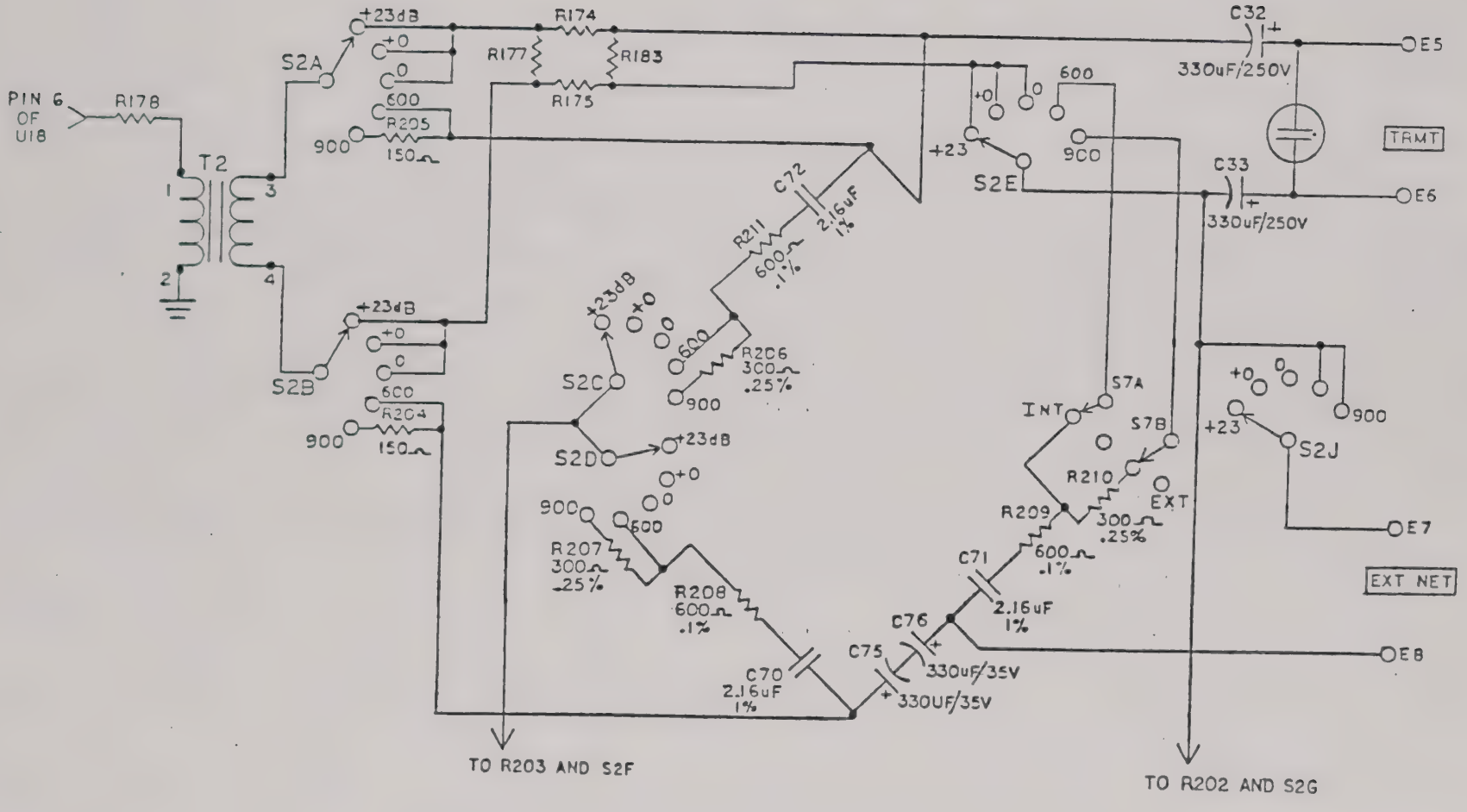


FIGURE 3-5 OUTPUT NETWORK

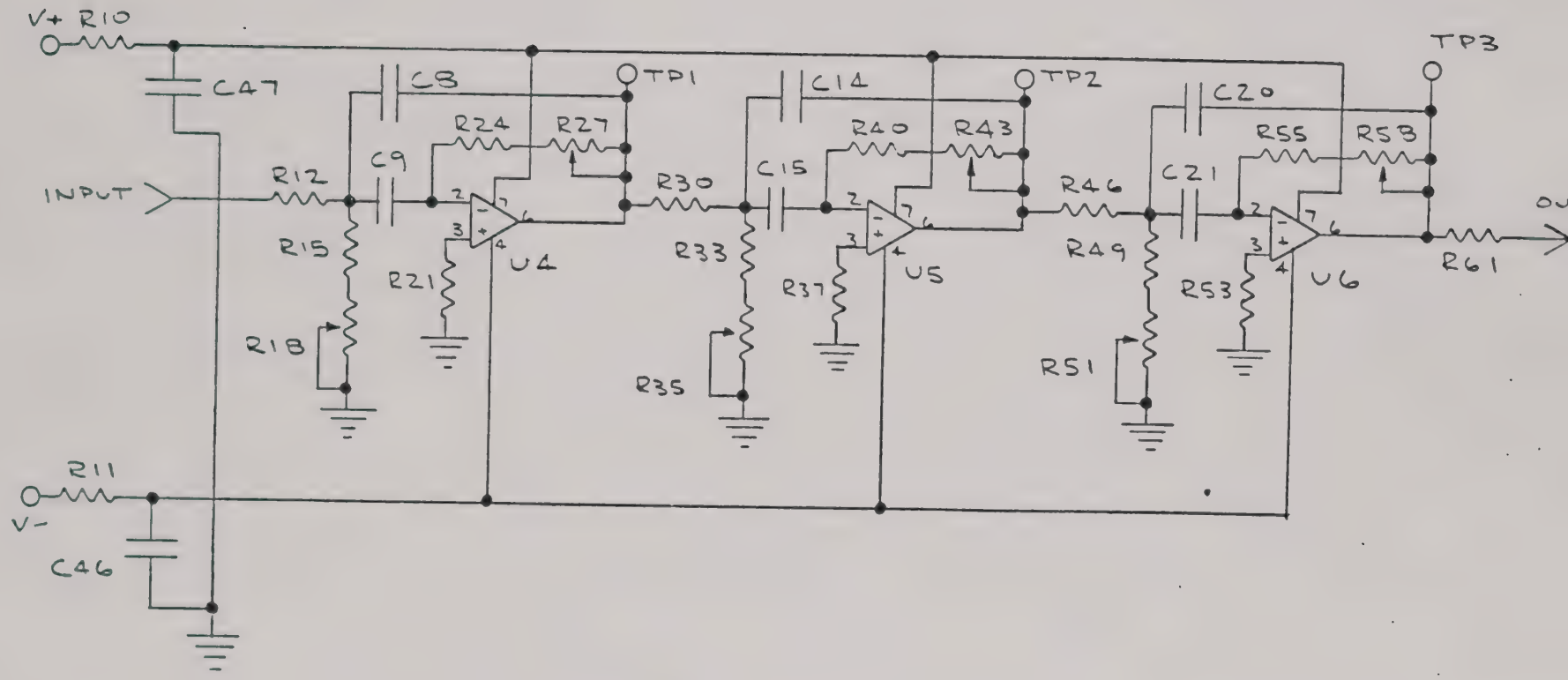


FIGURE 3-6 SRL HIGH FILTER

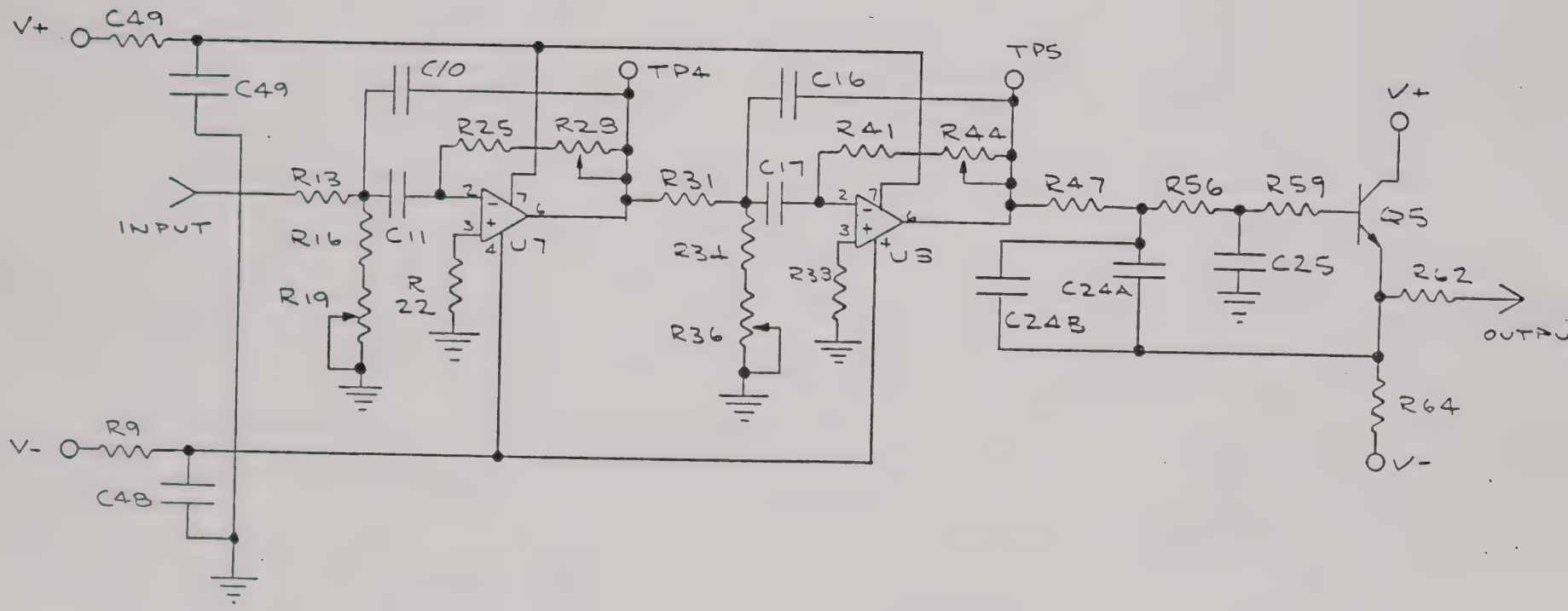


FIGURE 3-7 SRL FILTER

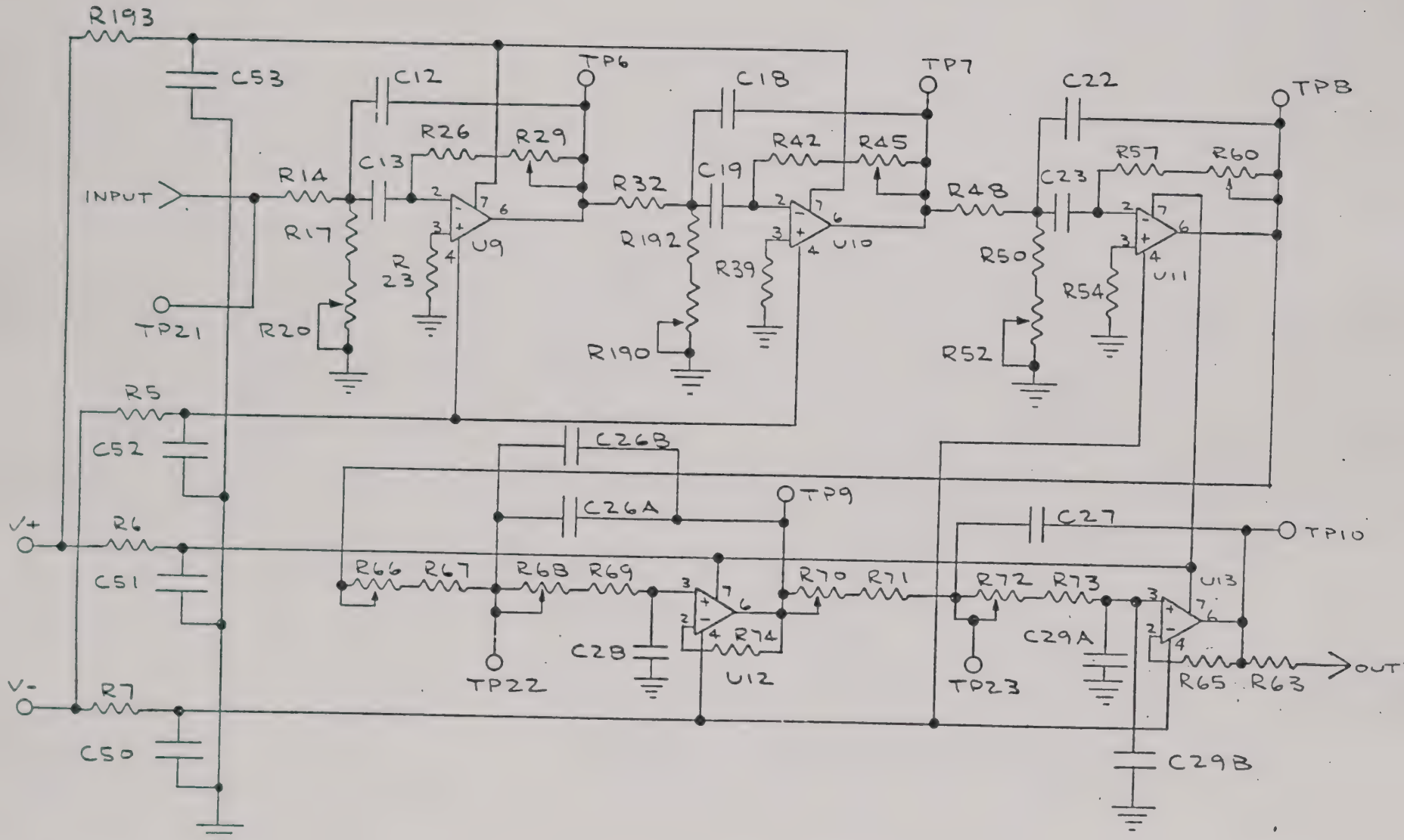


FIGURE 3-8 ERL FILTER

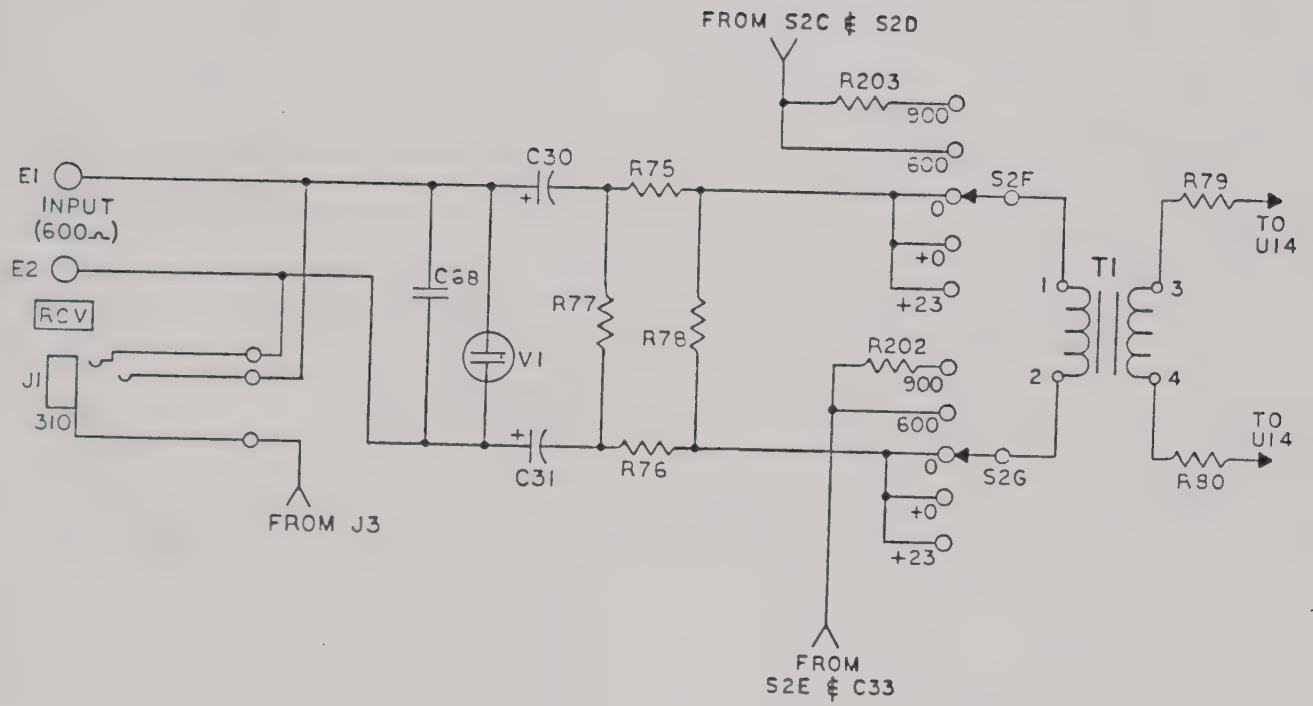


FIGURE 3-9 RECEIVER INPUT CIRCUIT

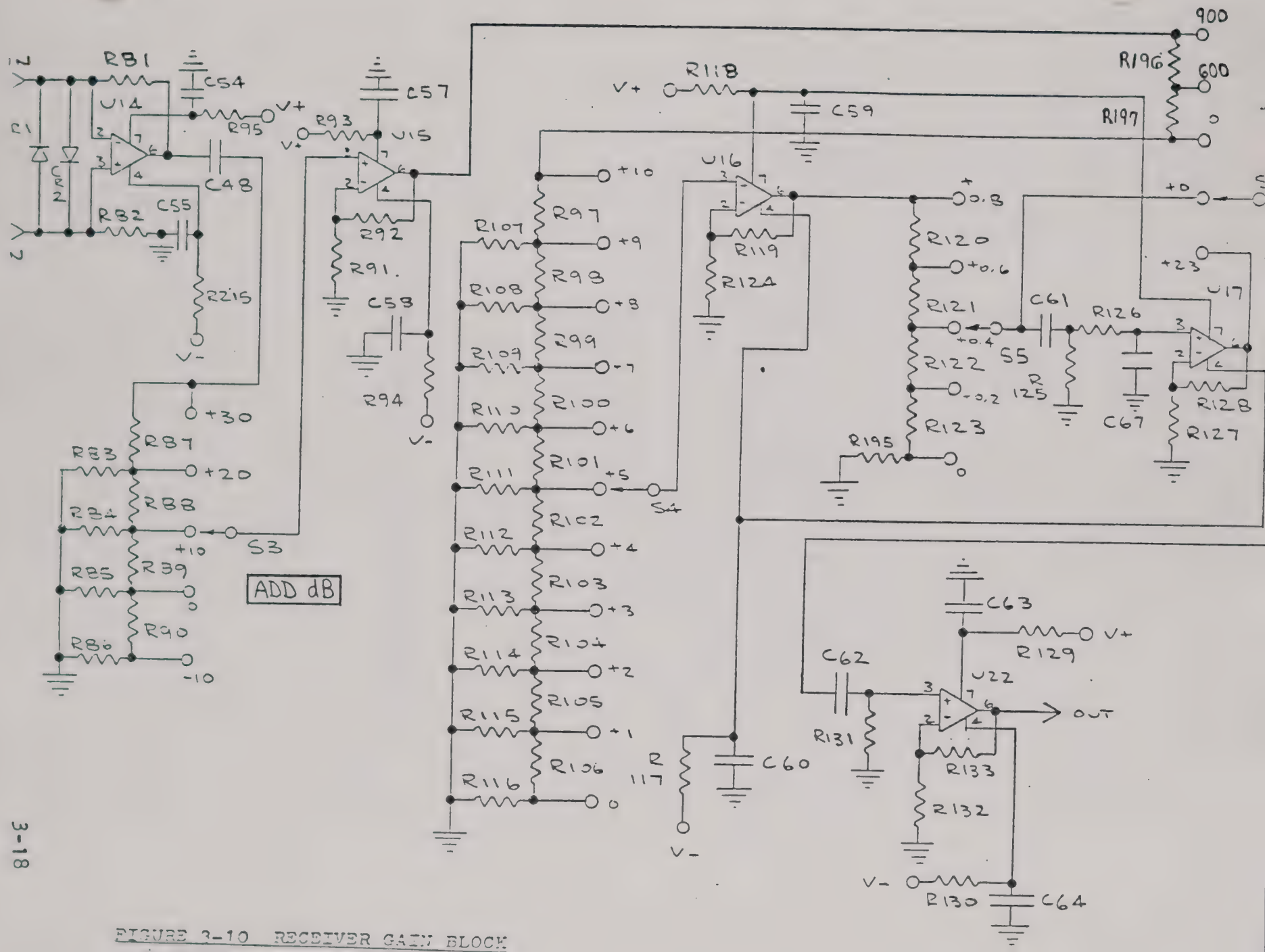


FIGURE 3-10 RECEIVER GAIN BLOCK

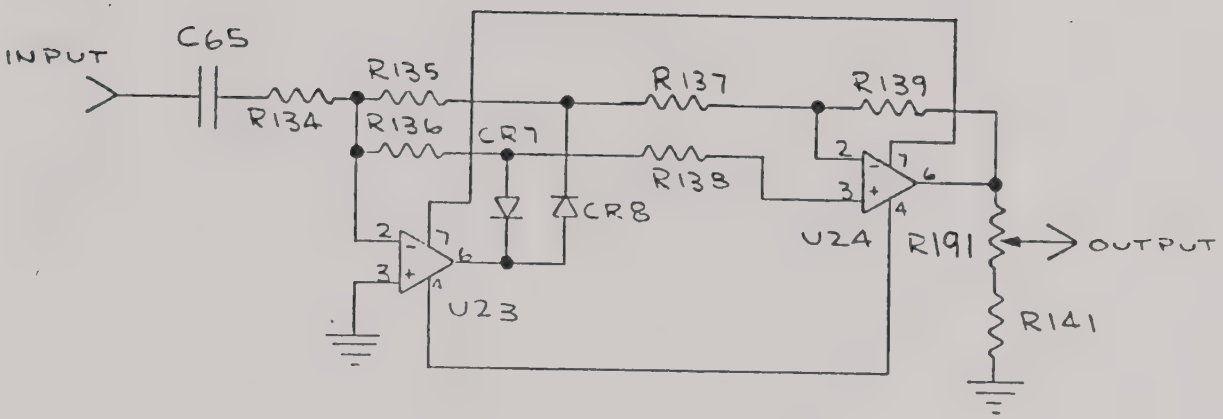


FIGURE 3-11 RECEIVER FULL-WAVE RECTIFIER

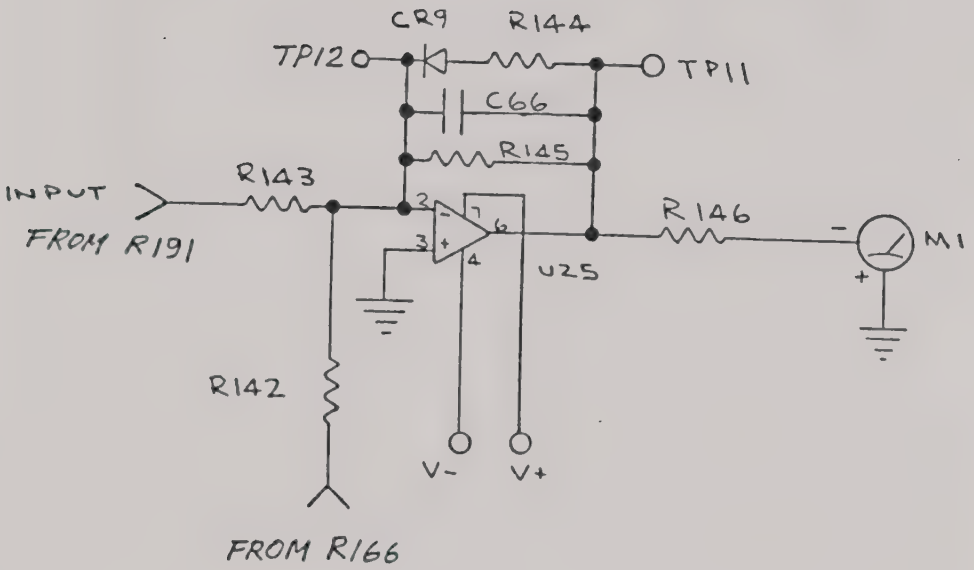


FIGURE 3-12 METER AMPLIFIER AND LOW-PASS FILTER

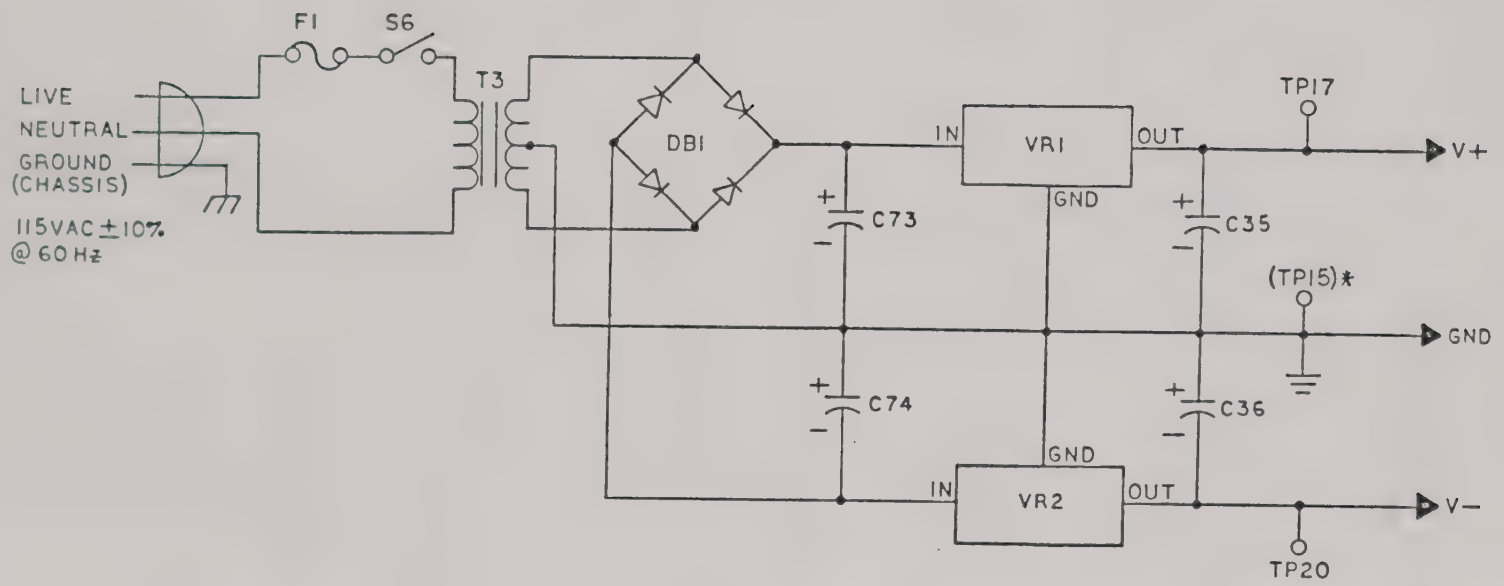


FIGURE 3-13 POWER SUPPLY

*SEE FIG. 3-2

4.0 MAINTENANCE

4.1 INTRODUCTION

This section contains the required test setups to measure unit performance and also provides adjustment and calibration procedures.

4.2 TEST EQUIPMENT REQUIRED

The test equipment required for maintenance of the Return Loss Measuring sets is outlined in Table 4-1; listed are the types of equipment to be used, the critical specifications, and the recommended commercially available units.

4.3 PERFORMANCE CHECKS

The test procedures described in 4.4 through 4.11.11 are to be performed with the L3A Return Loss Measuring Set mounted in the bottom half of the carrying case. With the detachable top cover removed, the bottom half of the carrying case can be placed on the table with the control panel in either horizontal or vertical position.

For calibration and some other test procedures, as described in 4.13 through 4.18.5, the case must be removed in order to get access to the printed circuit boards for adjustment and testing.

4.4 TRANSMITTER OUTPUT POWER LEVEL TEST

4.4.1 A vacuum tube voltmeter (VTVM), such as a Hewlett-Packard 400L, a 900 ohm ± 1% resistor, and a 600 ohm ± 1% resistor are needed for this test.

4.4.2 Connect the VTVM across the TRMT terminals of the Test Set.

4.4.3 Set the TEST LOCATION and TEST TYPE switches as listed below, and connect an appropriate resistor across the TRMT terminals. Check the average reading of the VTVM against the listed value. (The VTVM scale is calibrated for 600 ohm and 1 mW).

TEST LOCATION	TEST TYPE	RESISTANCE ACROSS TRMT TERMINALS	HP-400L VTVM READING
0 dB	ERL	600 OHMS	-5.4 dBm ± 0.2 dB
0 dB	SRL	600 OHMS	-5.4 dBm ± 0.2 dB
0 dB	SRL HI	600 OHMS	-5.4 dBm ± 0.2 dB
600	ERL	600 OHMS	-6.0 dBm ± 0.2 dB
900	ERL	900 OHMS	*-6.0 dBm ± 0.2 dB

* -7.8 dBm if the VTVM scale is calibrated for 900 ohm and 1 mW.

TABLE 4-1

TEST EQUIPMENT REQUIRED

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Audio Oscillator	Frequency Range: 25Hz to 25KHz Impedance: 600 Ω Max. Distortion: 0.2% 20Hz to 200KHz	External Oscillator Frequency Response Receiver Sensitivity Receiver Frequency Response Longitudinal Balance Filter Characteristics ERL, SRL, SRL HI Filter Test Output Impedance Test Input Impedance Test Meter Sensitivity Test	Hewlett-Packard 200CD
Vacuum Tube Voltmeter (VTVM)	Accuracy: within ±1% of full scale Meter: linear expanded dB scale Calibration: 1mW in 600 Ω	Ouput Level External Oscillator Frequency Response Receiver Sensitivity Receiver Frequency Response Longitudinal Balance Filter Characteristic Check ERL,SRL,SRL HI Filter Test Output Impedance Test Input Impedance Test Meter Sensitivity Test	Hewlett-Packard 400L
Decade Attenuator	Range: 0-111 dB in steps of 0.1 dB Accuracy:within 0.1 ±1% dB at 1KHz Impedance: 600 OHMS	Receiver Sensitivity Filter Charactersitics ERL,SRL,SRL HI Filter Test	General Radio 1450-TBR
Voltmeter	Range:5000V rms 5000V dc Accuracy: ±2% V dc full scale ±3% V ac full scale	Power Supplies Check	Simpson 260

TABLE 4-1 (Cont'd)

TEST EQUIPMENT REQUIRED

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Digital Frequency Counter	Frequency Range: 100Hz to 25KHz Accuracy: +0.3%	Filter Characteristics Check ERL, SRL, SRL HI Filter Adj.	General Radio 1192
Oscilloscope	Band Width: DC to 13 MHz Rise Time: 27 ns	Waveforms	Tektronix 531A CA Dual Trace Plug-In
Balancing Transformer		Longitudinal Balance	UTC A20
2.16uF capacitor	Accuracy: ±1%	Accuracy 2-Wire Network	
0.05uF capacitor	Accuracy: measured to ±1% absolute		
900Ω resistor	Accuracy: ±0.1%	Network	
900Ω resistor	Accuracy: ±1%	Terminating Load	RN65C9000F
600Ω resistor	Accuracy: ±1%	Terminating Load	RN65C6000F
150Ω resistor	Accuracy: ±1%	Network	RN65C1500F
150Ω resistor	Accuracy: ±5%	Balance	RC20GF151J
Adapter	GR double-plug	Network	General Radio Type 274-MB
Test Leads	GR to GR, 24"L. GR to alligator, 24"L. Banana to pin-tip, 24"L		H.H. Smith 1580-24 H.H. Smith 1581-24 Pomona Electronics 1126-24
	Pin-tip to pin-tip, 4"L		Pomona Electronics 1727-4

4.5 EXT OSC Frequency Response

4.5.1 An audio oscillator, such as a Hewlett-Packard 200 CD, a VTVM such as a Hewlett-Packard 400L, and a 600 ohm ±1% resistor are needed for this measurement.

4.5.2 Set the TEST LOCATION switch to 0 dB and TEST TYPE switch to EXT OSC.

4.5.3 Connect the audio oscillator and the VTVM each across the EXT OSC terminals.

4.5.4 Set the oscillator frequency to 1KHz and the output level to approximately 0 dBm, then disconnect the VTVM from the EXT OSC terminals.

4.5.5 Connect the VTVM and the 600 ohm ±1% resistor each across the TRMT output terminals.

4.5.6 The VTVM should read -5.4 dBm ± 0.2 dB. (If adjustment is needed follow section 4.14).

4.5.7 Vary the oscillator's frequency. The maximum amplitude excursion at the TRMT terminals should not exceed .4 dB from 200 Hz to 5 KHz and 1 dB from 100 Hz to 15 KHz.

4.6 Output Impedance Test

4.6.1 Repeat 4.5.1 through 4.5.6.

4.6.2 Disconnect the 600 ohm ±1% resistor from the TRMT output terminals; the VTVM should read 6.0 dB ±0.1 dB up from the reading observed in 4.5.6. (For example: -5.4 dBm +6.0 dB = +0.6 dBm).

4.7 Input Impedance Test

4.7.1 An audio oscillator, such as Hewlett-Packard 200 CD; a VTVM such as a Hewlett-Packard 400 L; and a 600 ohm ±1% resistor are needed to measure the input impedance.

4.7.2 Connect the equipment as shown in FIG. 4-2. Use caution to assure that the ground return is properly established.

4.7.3 Set the oscillator frequency to 1 KHz and adjust the level so that the VTVM reads 0 dBm across position 1 and the chassis ground.

4.7.4 Move the VTVM connection to Position 2 , the VTVM should read -6.0 dBm ±0.4 dB.

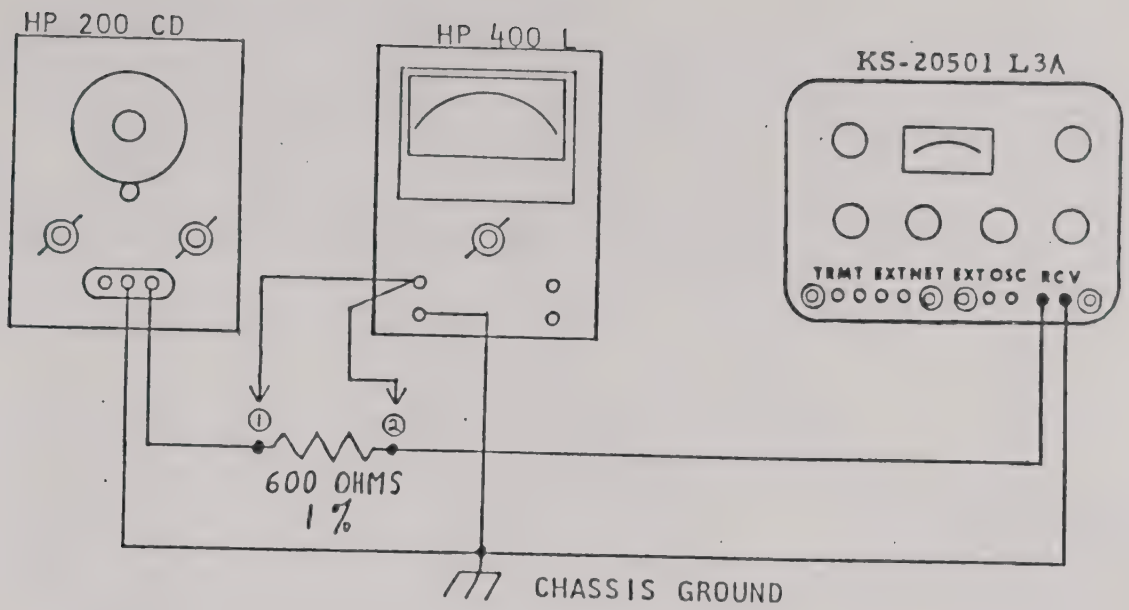


FIG. 4-2 Input Impedance Test

4.8 Receiver Frequency Response Test

4.8.1 An audio oscillator, such as a Hewlett-Packard 200 CD, a VTVM, such as a Hewlett-Packard 400 L, and a 24" test lead such as H.H. Smith 1580-24 are needed for this test.

4.8.2 Use the test lead to connect the RCV terminals to the EXT OSC terminals. Connect the oscillator and VTVM to the EXT OSC terminals. Use caution to assure that the ground return is properly established.

4.8.3 Set the TEST LOCATION switch to 0 dB, TEST TYPE switch to EXT OSC and ADD dB switch to 0.

4.8.4 Set the oscillator frequency to 1 KHz and adjust the output level to provide an indication of 0 dB on the RETURN LOSS dB meter. (Approximately -5.3 dBm output from the oscillator at 1 KHz).

4.8.5 Sweep the oscillator frequency from 100 Hz to 15 kHz and adjust the oscillator output level to keep the RETURN LOSS dB meter indication at 0 dB.
Note the excursions of the oscillator output on the VTVM.

4.8.6 The maximum excursion (from maximum to minimum) of the oscillator output level shall be 0.4 dB from 200 Hz to 5 kHz; 1 dB from 100 Hz to 15 kHz.

4.9 Receiver Gain Accuracy Test

4.9.1 An audio oscillator, such as a Hewlett-Packard 200 CD, a VTVM such as a Hewlett-Packard 400 L, and a Decade Attenuator, such as a General Radio 1450-TBR, will be needed for this test.

4.9.2 Connect the audio oscillator and the VTVM each across the EXT OSC terminals as shown in Figure 4-3.

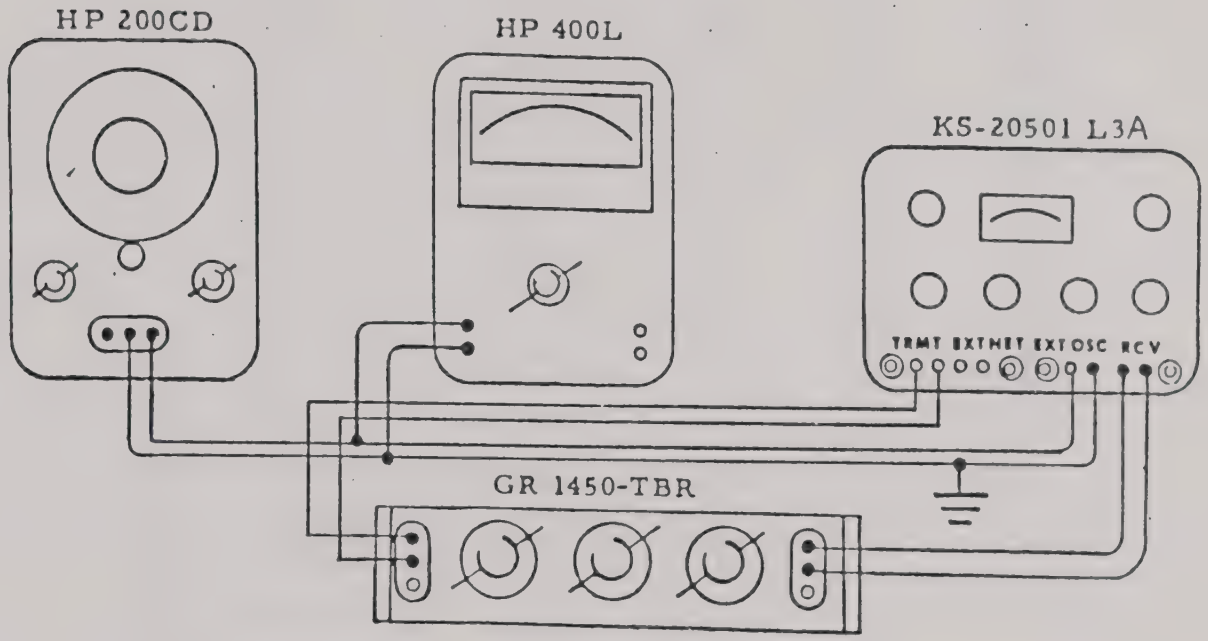


FIGURE 4-3 Receiver Gain Accuracy Test

4.9.3 Set the Oscillator frequency to 1 KHz and the output level to approximately 0 dBm across the EXT OSC terminals.

4.9.4 Connect the TRMT output to the Decade Attenuator input terminals. Connect the Decade Attenuator output to the RCV input terminals.

4.9.5 Set the Decade Attenuator to 0.0 dB and the L3A Set's controls as follows:

TEST LOCATION	0 dB
ADD dB	0
TEST TYPE	EXT OSC

The RETURN LOSS dB Meter indication should be 0.0 ±0.2 dB. If adjustment is needed, follow the procedures in 4.15.

4.9.6 With the combination of the L3A Set and Attenuator settings listed below, the RETURN LOSS dB Meter indication should not vary more than ±0.2 dB from the reading observed in 4.9.5.

TEST LOCATION (dB)	ADD dB	THL or ADD 1 dB	THL or ADD 0.2 dB	ATTENUATOR
+0 dB	-10	10	0	0.0
+0 dB	0	10	0	10.0
+0 dB	10	10	0	20.0
+0 dB	20	10	0	30.0
+0 dB	30	10	0	40.0
+0 dB	30	9	0	39.0
+0 dB	30	8	0	38.0
+0 dB	30	7	0	37.0
+0 dB	30	6	0	36.0
+0 dB	30	5	0	35.0
+0 dB	30	4	0	34.0
+0 dB	30	3	0	33.0
+0 dB	30	2	0	32.0
+0 dB	30	1	0	31.0
+0 dB	30	0	0.2	30.2
+0 dB	30	0	0.4	30.4
+0 dB	30	0	0.6	30.6
+0 dB	30	0	0.8	30.8
+0 dB	30	0	0	30.0
0 dB	30	0	0	30.0
+23 dB	0	0	0	23.0

4.9.7 Same equipment set-up as in Paragraphs 4.9.1 through 4.9.4.

4.9.8 Set the Decade Attenuator to 30.0 dB and the control switches of the L3A test set as follows:

TEST LOCATION	0 dB
ADD dB	+ 30
TEST TYPE	EXT OSC

4.9.9 Use each value listed in the "ATTENUATOR" column as a guide line to adjust the Decade Attenuator so that the RETURN LOSS dB meter indication is exactly the same as the corresponding value listed in the "dB METER" column. The actual setting of the Decade Attenuator should not vary more than ±0.2 dB from the one listed in the "ATTENUATOR" column.

ATTENUATOR	dB METER	ATTENUATOR	dB METER
30.0	0.0	35.5	5.5
30.5	0.5	36.0	6.0
31.0	1.0	36.5	6.5
31.5	1.5	37.0	7.0
32.0	2.0	37.5	7.5
32.5	2.5	38.0	8.0
33.0	3.0	38.5	8.5
33.5	3.5	39.0	9.0
34	4.0	39.5	9.5
34.5	4.5	40.0	10.0
35	5.0		

4.10 Accuracy of 2-Wire Measurements

4.10.1 Set TEST LOCATION switch to 600 , TEST TYPE switch to ERL, NETWORK switch to INT, and ADD dB switch to 0. The RETURN LOSS dB meter should indicate 0 ±0.2 dB.

4.10.2 Connect a shorting strap across the TRMT terminals or use a shorting type plug in the 310 jack. The RETURN LOSS dB meter should indicate 0 ±0.2 dB.

4.10.3 Set TEST LOCATION switch to 900 . The RETURN LOSS dB meter should indicate 0 ±0.2 dB.

4.10.4 Remove the short from the TRMT terminals or the 310 jack. The RETURN LOSS dB meter should indicate 0 ±0.2 dB.

4.10.5 Components needed for the following test include a 900Ω ±0.1% resistor and a network composed of a 900Ω±0.1% resistor in parallel with a 0.05uf ±1% capacitor.

4.10.6 Set NETWORK switch the INT.

4.10.7 The test network is connected to the TRMT terminals and the Test Set is operated as shown in the following table. All Return Loss readings should be ±0.4 dB of those shown on the table.

TEST LOCATION	TEST TYPE	Test Network	Return Loss-dB
900	ERL	900Ω//.05uF	15.7
900	SRL	900Ω//.05uF	23.1
900	SRL HI	900Ω//.05uF	8.9
900	ERL	900Ω	28.3
900	SRL	900Ω	18.9
900	SRL HI	900Ω	36.6

4.11 Longitudinal Balance Test

4.11.1 An audio oscillator, such as a Hewlett-Packard 200 CD, a VTVM, such as a Hewlett-Packard 400L, a balancing transformer, such as a U.T.C. Model A20, and a 150 ohm ±5% resistor are needed for this test.

4.11.2 Connect the Test Equipment as shown in FIG. 4-4

4.11.3 Set TEST LOCATION switch to 0 dB, TEST TYPE switch to EXT OSC, ADD dB switch to 0, and NETWORK switch to INT.

4.11.4 Disconnect R1 from chassis ground and connect the T and R terminals and the VTVM each across the TRMT terminals.

4.11.5 Set the oscillator frequency to 100 Hz and adjust the output level to obtain 0 dBm at V1.

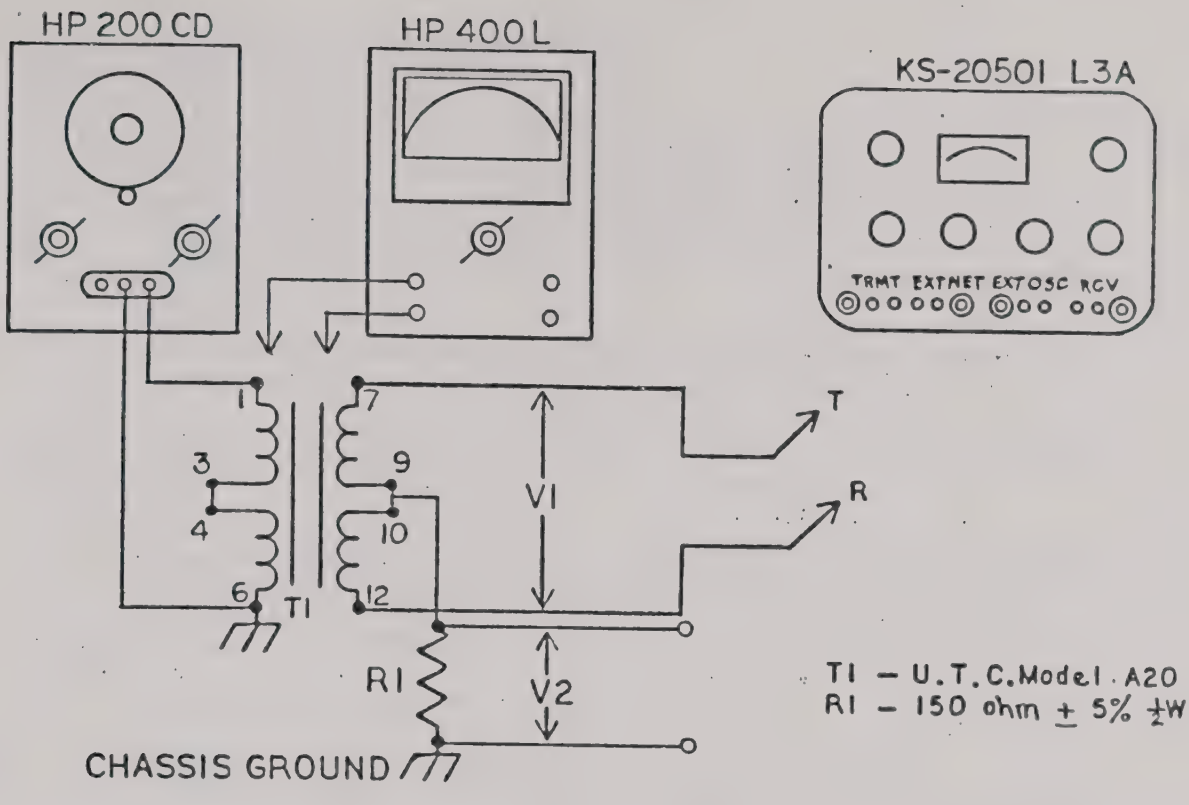


FIG. 4-4 LONGITUDINAL BALANCE TEST

4.11.6 Connect R1 back to chassis ground. Remove the VTVM from V1 and connect it to measure V2.

4.11.7 The absolute value of the voltage measured at V2 in dB is the longitudinal balance at the frequency used. (Note that V2 is a low-level signal, it is important to avoid any noise pick-up which can cause inaccurate measurement.)

4.11.8 Repeat 4.11.3 through 4.11.7 with oscillator frequency set to 3000 Hz. Verify that the longitudinal balance is greater than 70 dB at 100 Hz and 55 dB at 3000 Hz.

4.11.9 Repeat 4.11.3 through 4.11.8 using the RCV terminals instead of the TRMT terminals.

4.11.10 Repeat 4.11.3 through 4.11.8 with the TEST LOCATION switch in the 600 position.

4.11.11 Repeat 4.11.3 through 4.11.8 with the TEST LOCATION switch in the 900 position.

4.12 Front Panel Removal

4.12.1 Under normal operation and performance tests, there is no need to remove the L3A test set from its case; the detachable top cover may be removed for convenience. However, for adjustment and calibration procedures as described in 4.13 through 4.18.5, it is necessary to remove the front panel from the case in order to get access to the printed circuit boards.

4.12.2 With the POWER switch in the OFF position, disconnect the power cord from the 115 VAC power outlet.

4.12.3 Remove the detachable cover of the case. Remove the mounting screws of the front panel.

4.12.4 Turn the L3A set upside-down on a padded surface; then lift the bottom half of the carrying case from the front panel on which the printed circuit boards and controls are mounted.

4.12.5 Reverse the procedure to replace the case.

4.13 Power Supply Test (See Fig. 3-13)

4.13.1 Connect a DC voltmeter (with pin-tip probes) across test points TP17 and TP15, the voltmeter should read +12.0 ±0.7V.

4.13.2 Connect a DC voltmeter across test points TP20 and TP15, it should read -12.0 ±0.7V.

4.14 Output Level Adjustment (See Fig. 3-4)

4.14.1 Repeat 4.5.1 through 4.5.6.

4.14.2 Adjust R171 to read -5.4 dBm ±0.1 dB on the VTVM.

4.14.3 With the TEST TYPE switch set to ERL, SRL, or SRL HI, the average of the VTVM reading should be -5.4 dBm ±0.2 dB.

4.15 dB Meter Sensitivity Adjustment (See Figures 3-4 and 3-11)

4.15.1 Repeat 4.9.1 through 4.9.5.

4.15.2 With the Decade Attenuator set to 0.0 dB, adjust R191 for the RETURN LOSS dB Meter to read 0.0 dB.

4.15.3 With the Decade Attenuator set to 10.0 dB, adjust R166 for the dB Meter to read 10.0 dB.

4.15.4 Repeat 4.15.2 and 4.15.3 as needed.

4.16 ERL Filter Characteristics Test (See Figures 3-2 and 3-3)

4.16.1 Equipment needed for this test:
Audio Oscillator (Hewlett-Packard 200 CD)
Digital Frequency Counter (General Radio 1192)
VTVM (Hewlett-Packard 400L)
Banana-plug to pin-tip patch cords, 24" or 36" long. Four pieces are required. (Pomona Electronics 1126-24 or 1126-36)
One pin-tip stacking patch cord, 4" long. (Pomona Electronics Model 1727-4).

4.16.2 Connect the 4 inch stacking patch cord across test points TP14 and TP15. (TP15 is electronic circuit ground.)

4.16.3 Connect the Audio Oscillator output to the Digital Frequency Counter input terminals.

4.16.4 Use two banana-plug to pin-tip patch cords to connect the oscillator output high terminal to TP19 and the low terminal to TP15.

4.16.5 Use the other two patch cords to connect the high input terminal of VTVM to TP18 and low input to TP15.

4.16.6 Set the TEST TYPE switch to ERL.

4.16.7 Set the oscillator frequency to 1000 Hz and adjust the output level to read 0 dBm on VTVM.

4.16.8 Vary the oscillator frequency from 200 Hz to 5000 Hz, and verify the following filter characteristics.

ERL FILTER RESPONSE

Frequency Hz	Loss* dB	Tolerance dB
≤ 200	> 30	-
300	21.8	±2.3
560	3	±0.4
750	0.2	±0.2
1000	0	±0.1
1500	0.1	±0.2
1965	3	±0.4
2400	10.9	±1.2
3000	22.9	±3.0
4000	42.6	±5.0
≥5000	> 45	-

*Excluding any flat insertion loss.

4.16.9 Be sure to disconnect the 4 inch patch cord from TP14 and TP15 if no more filter characteristics tests will be performed.

4.17 SRL Filter Characteristics Test (See Figures 3-2 and 3-3)

4.17.1 Repeat 4.16.1 through 4.16.5.

4.17.2 Set the TEST TYPE switch to SRL.

4.17.3 Set the oscillator frequency to 360 Hz and adjust the output level to read 0 dBm on VTVM.

4.17.4 Vary the oscillator frequency from 100 Hz to 1200 Hz, and verify the following filter characteristics.

SRL FILTER RESPONSE

Frequency Hz	Loss* dB	Tolerance dB
≤120	>20	-
200	9.5	±1.1
260	3	±0.5
360	0	±0.2
500	3	±0.5
650	10	±1.2
≥1000	>20	-

*Excluding any flat insertion loss.

4.17.5 Repeat 4.16.9.

4.18 SRL HI Filter Characteristics Test (See Figures 3-2 and 3-3)

4.18.1 Repeat 4.16.1 through 4.16.5.

4.18.2 Set the TEST TYPE switch to SRL HI.

4.18.3 Set the oscillator frequency to 2700 Hz and adjust the output level to read 0 dBm on VTVM.

4.18.4 Vary the oscillator frequency from 1000 Hz to 6000 Hz, and verify the following filter characteristics.

SRL HI FILTER RESPONSE

Frequency Hz	Loss* dB	Tolerance dB
≤1300	>30	-
2000	11.5	±1.3
2200	3	±0.5
2700	0	±0.2
3400	3	±0.5
3700	10.9	±1.3
≥5700	>30	-

*Excluding any flat insertion loss.

4.18.5 Repeat 4.16.9.

5.0 TROUBLESHOOTING TECHNIQUES

5.1 GENERAL

This section is designed to aid in the isolation of possible malfunctions of the KS-20501 L3A RETURN LOSS MEASURING SET. The circuitry of the L3A Set may be sectioned into three, namely, the Transmit Section, the Receive Section, and the Power Supply. Although it appears to be simple to troubleshoot from front panel symptoms, the results are often inconclusive. An effective way to isolate the problem area is to check the output level across the TRMT output terminals. (Sections 4.4 and 4.5). If the Transmit Section is working properly, skip the Power Supply and go directly to Section 5.9 to troubleshoot the Receiver Section. Otherwise follow the troubleshooting procedures for the Power Supply and the Transmit Section.

It is assumed that the person who troubleshoots and repairs the L3A Set is familiar with the L3A Set and all necessary test equipment. Read Section 4.0 through Section 4.18. For this reason, no further description on equipment set-up will be given.

5.2 POWER SUPPLY (See Figure 3-13)

5.2.1 Repeat Section 4.13. (If the power supply is working properly, go to Section 5.3.)

5.2.2 If voltages are zero, check fuse F1 and line voltage for 117 VAC $\pm$ 10%.

5.2.3 Check the voltage across capacitor C73 for approximately +18.5 VDC. (At least +15.0 VDC for minimum line voltage).

5.2.4 Check the positive voltage regulator VR1.

5.2.5 Similar to above, check C74 and VR2 for the -12 VDC supply.

5.3 TRANSMIT SECTION

5.3.1 If the output level of all four test signals (EXT OSC, ERL, SRL, and SRL HI) are either too high or too low by the same percentage, repeat Section 4.14.

5.3.2 If the output of EXT OSC test signal is normal and all three other test signals are abnormal - - - zero or saturated, follow the procedure in Section 5.4.

5.3.3 If the output of EXT OSC test signal is abnormal, follow the procedure in Section 5.5.

5.3.4 If all four test signals are not functioning properly, follow the procedures in Section 5.6 and Section 5.7.

5.3.5 If the performance of either ERL, SRL, or SRL Hl is in question, follow the procedure in Section 5.8.

5.4 NOISE GENERATOR AND AGC (Refer to Figures 3-2, 3-2A, 3-3 and 3-4)

5.4.1 The output waveform at pin 2 of the "C" Board Assembly should be a square wave of pseudo random width. Its voltage swing is between about ground and slightly below V+.

5.4.2 Both the noise level at TP19, TP21 and the DC level at the cathode of CR3 should vary by adjusting R171. If any one of these failed the test, check the associated components.

5.5 EXT OSC AND AMPLIFIER (Refer to Figures 3-2B, 3-3 and 3-4)

5.5.1 Repeat 4.5.1 through 4.5.6.

5.5.2 Adjust R171 to read -5.4 dBm ±0.1 dB on the VTVM. If R171 has no effect on the TRMT output level, then examine the waveform across TP18 and the electronic circuit ground TP15. The waveform should be an undistorted sinewave whose magnitude can be varied by adjusting R171. If the sinewave is absent, then trace the signal, starting from the EXT OSC terminals to R1, C1, Q6, S1, and TP18.

5.5.3 If an undistorted sinewave is present across TP18 and TP15, but is magnitude cannot be varied by adjusting R171, then check Q6, R3, R4, U18 (Voltage gain = 15.7), and Section 5.6.

5.6 TRANSMITTER FULL-WAVE RECTIFIER AND LOW-PASS FILTER

5.6.1 REPEAT 4.5.1 THROUGH 4.5.6.

5.6.2 The input waveform should be an undistorted sinewave. (See Section 5.5).

5.6.3 The voltage at the cathode of CR5 should resemble a positive going half wave, as shown in Figure 6-8.

5.6.4 The voltage at the anode of CR6 should resemble a negative going half wave, as shown in Figure 6-9.

5.6.5 The voltage at pin 6 of U20 should be a positive going full wave rectified signal. (See Figure 6-6).

5.6.6 The voltage at pin 6 of U21 should be a DC level which can be varied by adjusting R171.

5.6.7 The DC voltage across Z1 should be 6.2 ± 0.5 VDC.

5.7 TRANSMITTER OUTPUT NETWORK (Refer to Fig. 3-5)

5.7.1 Repeat Section 5.5 and/or Section 5.6 if needed.

5.7.2 Trace the sinewave from T2 towards the TRMT terminals. Use this signal as a guide to locate any defective components in the 4-wire output network.

5.7.3 Set the TEST LOCATION switch to the 600 ohm position, NETWORK switch to INT, and trace the sinewave from T2 towards the TRMT terminals. Use this signal as a guide to locate any defective components in the 600 ohm bridge for 2-wire measurements.

5.7.4 To troubleshoot the 900 ohm bridge, repeat 5.7.3, but the TEST LOCATION switch is set to the 900 ohm position.

5.7.5 Set switches as follows:

TEST LOCATION	900
TEST TYPE	SRL
NETWORK	EXT

Connect a test network across the TRMT terminals, and an appropriate reference network across the EXT NET terminals so that on-scale SRL reading is possible by adjusting the ADD dB switch.

Interchange these two networks. If the SRL reading changes by more than 0.4 dB, check C32, C33, C75, C76, and V2.

5.8 ERL, SRL, AND SRL HI FILTERS

5.8.1 To check the ERL filter characteristics, follow the procedure in Section 4.16.

5.8.2 The filters are adjusted at the factory. If the deviations observed are outside the tolerances given, the set should be returned to the manufacturer for repair.

5.8.3 To check the SRL or SRL III filter characteristics, follow the procedure in Section 4.17 or Section 4.18 respectively.

5.9 RECEIVER SECTION - - - GAIN BLOCK (Figure 3-10)

5.9.1 Connect an audio oscillator to the Receiver input terminals.

5.9.2 Adjust oscillator for 1 KHz and -45.5 dBm.

5.9.3 Set S2 (TEST LOCATION) to +23 dB. The signal level at U14 pin 6 as measured with a VTVM should be -30 dBm ±2 dB.

5.9.4 With appropriate settings, the signal at the arm of S3 (ADD dB) as measured with a VTVM should be as follows:

S3 Setting	VTVM Reading dB ± 2dB
+30	-30
+20	-40
+10	-50
0	-60
-10	-70

5.9.5 With S3 set to 0, the level at U15 pin 6 should read -41.9 ± 2 dB. (Note: S2 remains at the +23 dB position).

5.9.6 With appropriate settings, the signal at the arm of S4 (THL or ADD) as measured with a VTVM should be as follows:

S4 Setting	VTVM Reading dB ± 2 dB
+10	-46.8
+9	-47.8
+8	-48.8
+7	-49.8
+6	-50.8
+5	-51.8
+4	-52.8
+3	-53.8
+2	-54.8
+1	-55.8
0	-56.8

5.9.7 With S4 set to 0, the signal level at U16 pin 6 should be -46.0 ± 2 dB. (Note: S2 set to +23 dB and S3 set to 0).

5.9.8 With the appropriate settings, the signal at the arm of S5 (THL or ADD), as measured with a VTVM should be as follows:

S5 Setting	Meter Reading dB ± 2 dB
+0.8	-46.0
+0.6	-46.2
+0.4	-46.4
+0.2	-46.6
0	-46.8

5.9.9 With S5 set to 0, the signal level at U17 pin 6 should be -23.8 ± 2 dB. (Note: S2 set to +23 dB; S3 and S4 set to 0).

5.9.10 The signal at U22 pin 6 should be -10.6 ±2 dB.

5.10 RECEIVER SECTION - - - FULL-WAVE RECTIFIER(Figure 3-11)

5.10.1 Repeat 5.9.1 and 5.9.2

5.10.2 Set switches as follows

ADD dB	0
TEST LOCATION	+23 dB
THL or ADD	0.0

5.10.3 The voltage at the cathode of CR8 should resemble a half-wave positive going signal, as shown in Figure 6-11.

5.10.4 The voltage at the anode of CR7 should resemble a half-wave negative going signal, as shown in Figure 6-10.

5.10.5 The output voltage at U24 pin 6 should be a negative going full-wave signal. (See Figure 6-7).

5.11 RECEIVER SECTION - - - METER AMPLIFIER (Figure 3-12)

5.11.1 The input signal from R191 should be a rectified negative going full-wave signal.

5.11.2 The input signal from R166 should be a rectified positive going full-wave signal.

5.11.3 The output signal at pin 6 of U25 should be a DC level between 0 and -9.2 $\pm$ 0.18 VDC.

6.0 DRAWINGS AND WAVEFORMS

6.1 General

This section contains the main schematic diagram and typical voltages and waveforms for the KS-20501 L3A Return Loss Measuring Set.

6.2 Drawings

The main schematic diagram is shown in Figure 6-1.

The block diagram is shown in Figure 3-1 and the drawings for individual building blocks are shown in Figure 3-2 through Figure 3-13.

6.3 Waveforms

With sinewave applied to the RCV input terminals, the output waveform at pin 6 of U14, U15, U16, U17, and U22 should be sinusoidal and free from distortion.

Listed below are some other waveforms:

Figure 6-2	Waveform at TP14
Figure 6-3	ERL Waveform at Pin 6 of U18
Figure 6-4	SRL Waveform at Pin 6 of U18
Figure 6-5	SRL HI Waveform at Pin 6 of U18
Figure 6-6	Waveform at Pin 6 of U20
Figure 6-7	Waveform at Pin 6 of U24
Figure 6-8	Waveform at Cathode of CR5
Figure 6-9	Waveform at Anode of CR6
Figure 6-10	Waveform at Anode of CR7
Figure 6-11	Waveform at Cathode of CR8

6.4 Typical Voltages

6.4.1 The voltage at pin 3 of the "C" Board Assembly and pin 7 of all operational amplifiers should read +12.0 ±0.8VDC.

The voltage at pin 4 of all operational amplifiers should read -12.0 ±0.8VDC.

6.4.2 The DC level at pin 6 of U14, U15, U16, U17, U18, and U22 should be negligible.

The "baseline" of the waveforms at pin 6 of U20, pin 6 of U24, cathode of CR5, anode of CR6, anode of CR7, and cathode of CR8 should have negligible DC shift.

6.4.3 For AC signal level at various points, see MAINTENANCE in Section 4 and TROUBLESHOOTING TECHNIQUES in Section 5.

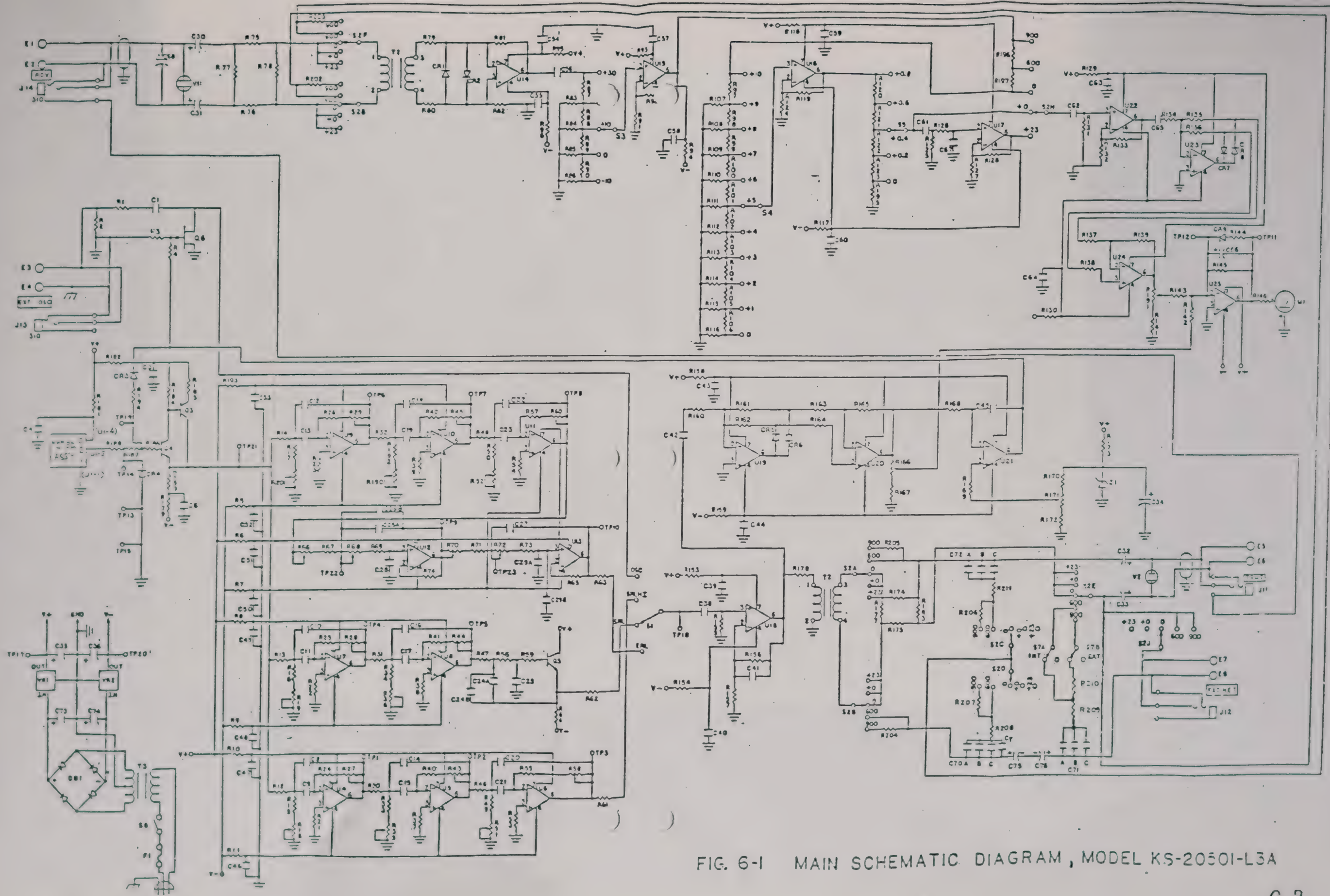
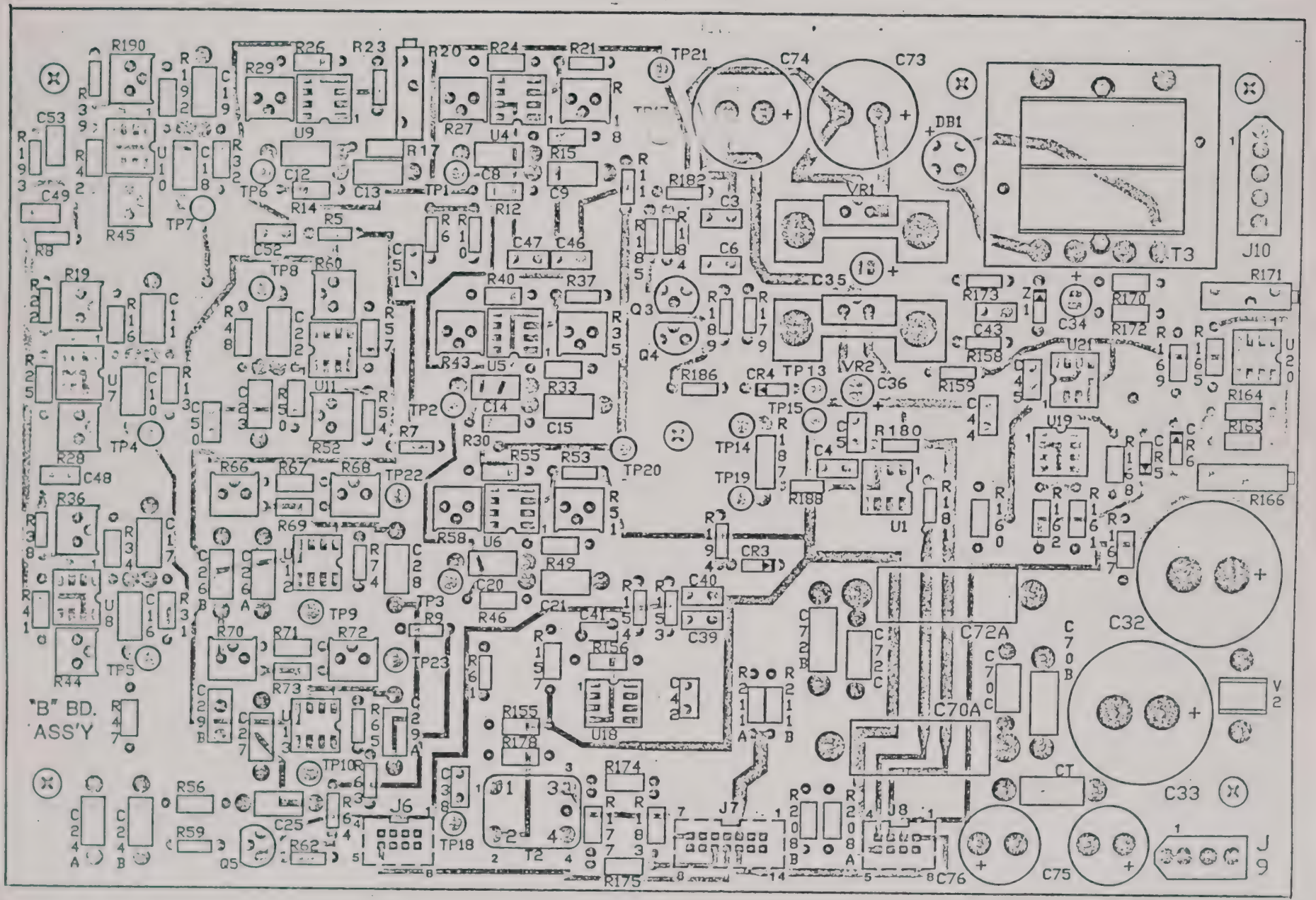


FIG. 6-1 MAIN SCHEMATIC DIAGRAM, MODEL KS-20501-L3A


"B" BD. ASS'Y
R190
R26
R23
R20
R24
R21
TP21
C74
C73
DB1
C53
R29
U9
R27
U4
R15
R182
VR1
T3
J10
R193
R192
R199
R17
C49
R42
U10
C18
R32
C12
C8
C9
C3
R45
TP7
TP6
TP1
R14
R5
R12
R8
C52
C47
C46
C6
C35
R171
R19
TP8
R60
R40
R37
Q3
R173
C34
R170
R22
R16
C11
R48
C22
R57
R43
U5
R35
Q4
C43
R158
U21
R172
R169
R165
U20
R25
U7
C10
R13
R186
CR4
TP13
VR2
C36
R159
R164
C23
C50
R54
U11
R33
TP15
C44
C45
R163
TP4
R52
C14
C15
R7
R30
R55
R53
TP20
TP14
R180
C5
U19
R28
C48
R66
R67
R68
TP22
TP19
R188
C4
R168
C56
R166
R36
R69
R58
U6
U1
R191
R34
R49
CR3
R38
C17
C26B
C26A
C28
C40
C32
R41
U12
R74
TP3
C20
R46
C21
C41
C39
C72A
R44
U8
C16
TP9
R9
R156
C72B
C72C
C70B
C70C
TP5
R70
R71
R72
TP23
R61
R155
C70A
R73
C29B
C27
C29A
R65
R178
R211A
R211B
V2
R47
TP10
R174
C38
R56
J6
J7
J8
CI
C33
C24A
C24B
R64
C25
R59
TP18
R207
R208B
R208A
R63
R62
T2
R175
C76
C75
J9
Q5

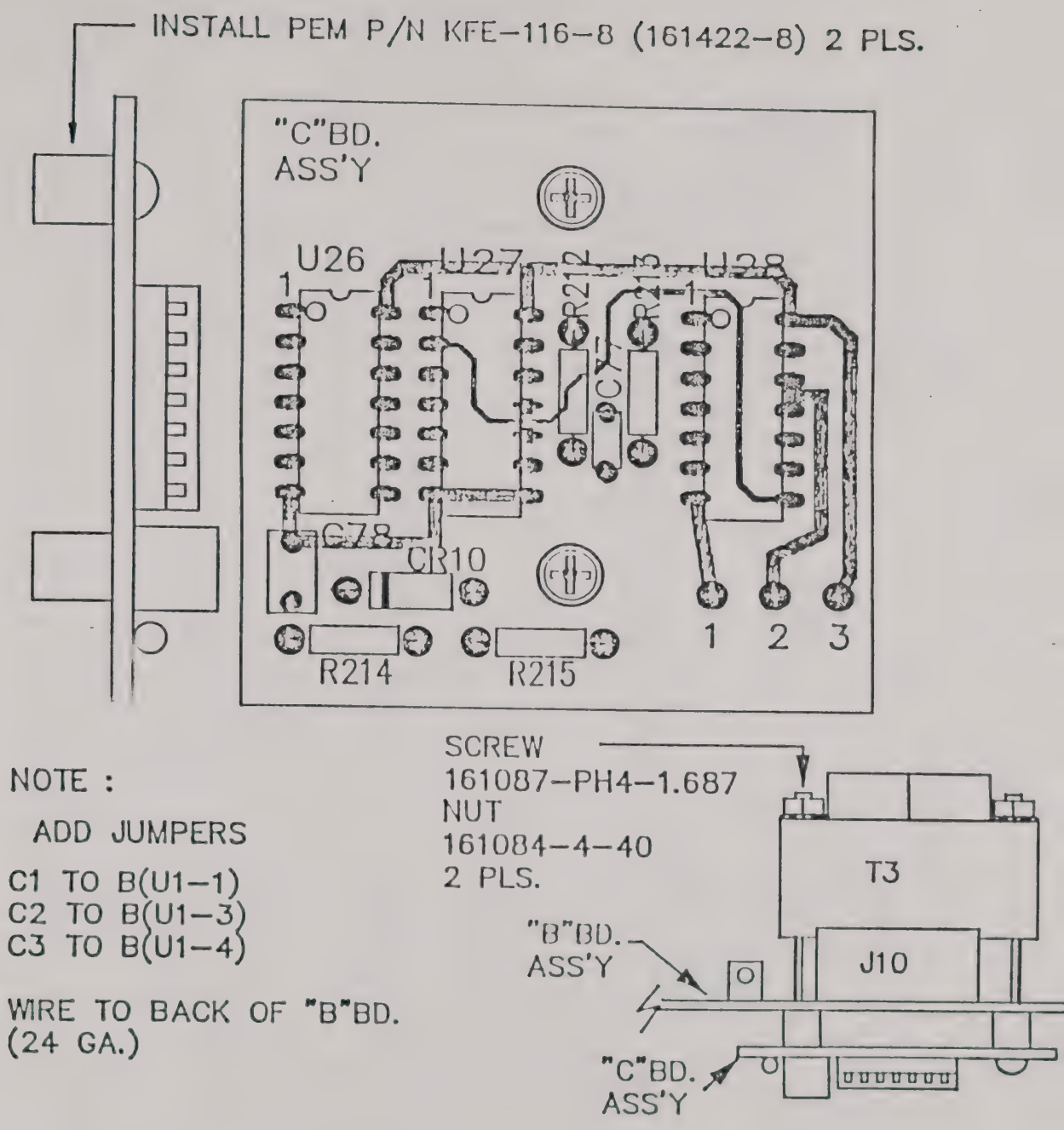


FIG. 6-13A "C" BOARD ASSEMBLY DRAWING

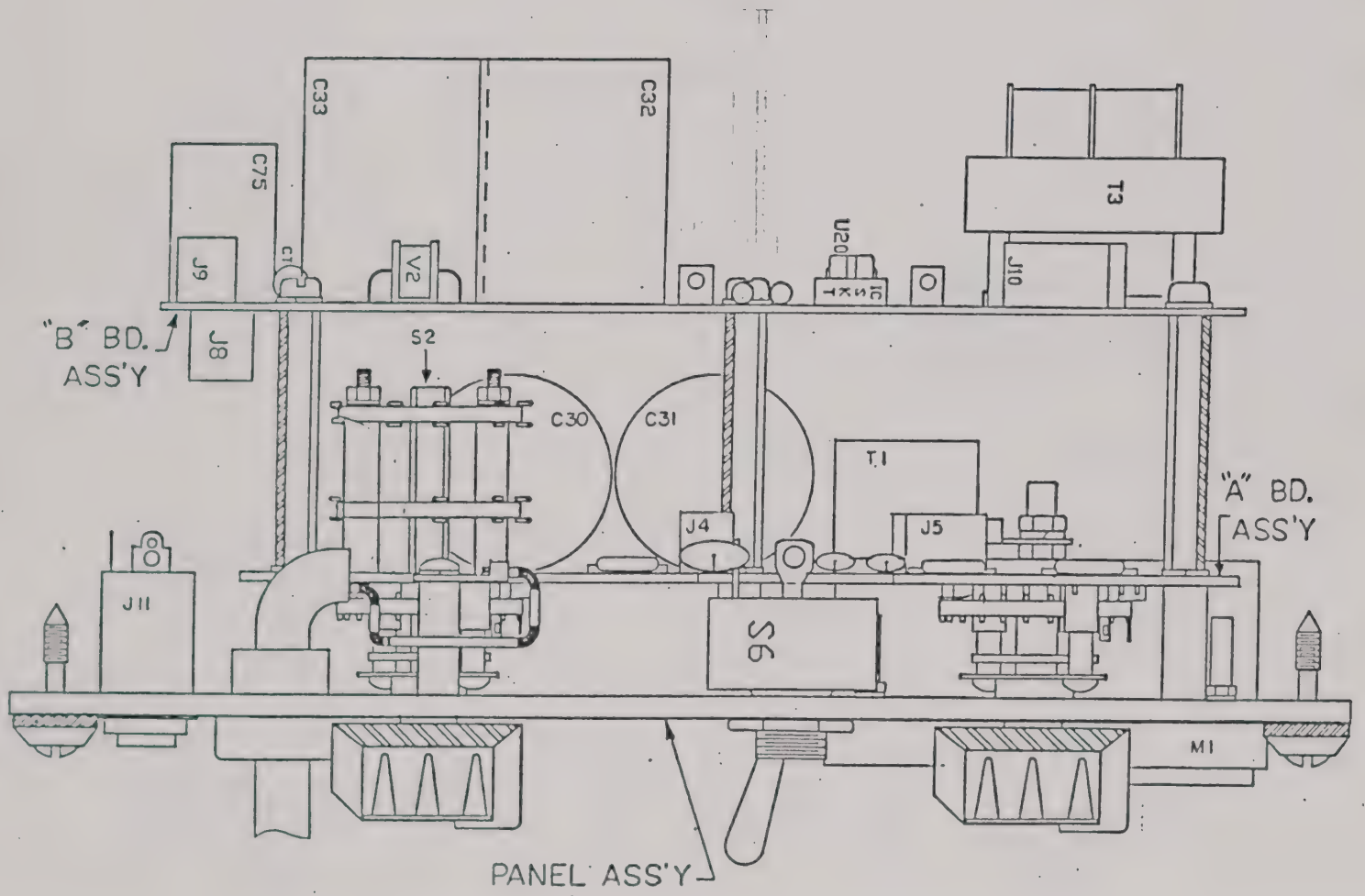


FIG. 6-14 CHASSIS ASSEMBLY DRAWING

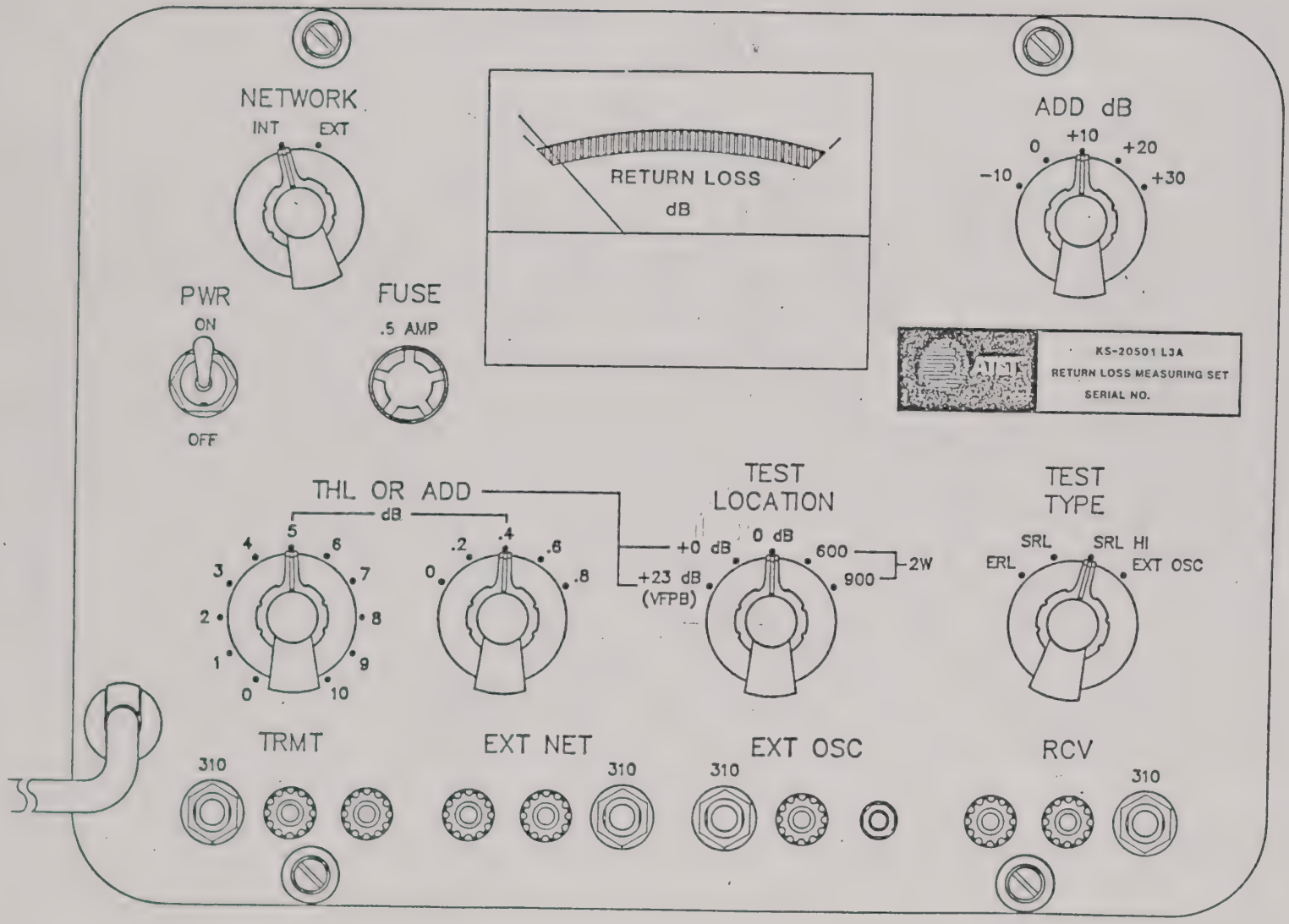


FIG. 6-15 L3A TEST SET FRONT PANEL

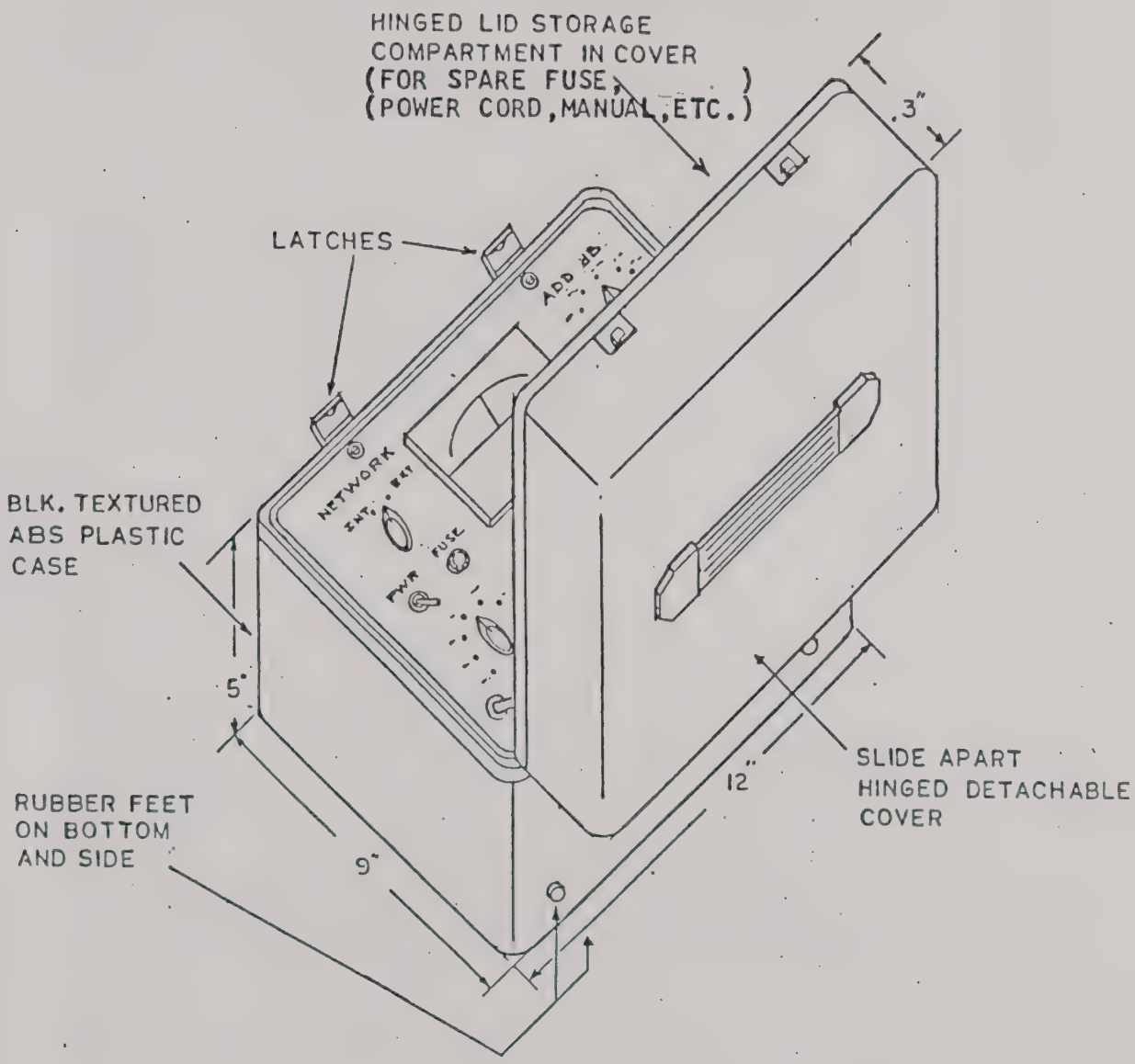


FIG. 6-16 L3A TEST SET CARRYING CASE

PARTS LIST

"A" BOARD ASS'Y

SYMBOL NUMBER	QTY.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
U14-17	4	Integrated Circuit, OP-AMP.	National	LF356N
U22-25	4	Integrated Circuit, OP-AMP.	RCA	CA3140AE
Q6	1	JFET, P-CHANNEL		2N5461
V1	1	Surge Arrestor	CP Clare	CG2-145L
CR1,2,CR7-9	5	Diode		1N483B
T1	1	Transformer	Tempo Instrument Inc.	260962
C1,56,65	3	Capacitor, 1UF/50V, 20%	Centralab	CZ30C105M
C30,31	2	Capacitor, 50UF/250VDC	Sprague	39D506F250JE4
C54,55,C57-64	10	Capacitor, .22UF/50V, 20%	Centralab	CZ20C224M
C66	1	Capacitor, 2.2UF/35, 10%	Sprague	CS13BF225M
C67	1	Capacitor, 270PF/1000V	Sprague	5GA-T27
C68	1	Capacitor, .0047/500V	Sprague	5GA-D47
C71A	1	Capacitor, 2.0UF/100V, 1%	Electrocube	650B1B205F
C71B	1	Capacitor, .15UF/100V, 1%	Electrocube	650B1B154F
C71C	1	Capacitor, .01UF/100V, 2%	Electrocube	650B1B103G
R1	1	Resistor, 10K, ½W		RC20G-103K
R2	1	Resistor, 680 OHMS, ½W		RC20G-681K
R3	1	Resistor, 22K, 1/4W		RC07G-223K
R4,126	2	Resistor, 10K, 1/4W		RC07G-103K
R75,76	2	Resistor, 196 OHMS, 1%		MF55C-1960F
R77,78	2	Resistor, 2.00K, 1%		MF55C-2001F
R79,80	2	Resistor, 243 OHMS, 1%		MF55C-2430F
R81,82	2	Resistor, 3.32K, 1%		MF55C-3321F
R83-85	3	Resistor, 10.0K, .5%		MF55C-1002D
R86	1	Resistor, 6.81K, .5%		MF55C-6811D
R87-90,107-115, 119,128	15	Resistor, 14.7K, .5%		MF55C-1472D
R91	1	Resistor, 2.10K, 1%		MF55C-2101F

PARTS LIST

"A" BOARD ASS'Y (Cont'd)

SYMBOL NUMBER	QTY.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
R92,R133-139	8	Resistor, 14.7K, 1%		MF55C-1472F
R93-96,117, 118,129,130	8	Resistor, 100 OHMS, 1/4W		RC07G-101K
R97-106	10	Resistor, 196 OHMS, .5%		MF55C-1960D
R116	1	Resistor, 1.60K, .5%		MF55C-1601D
R120-123	4	Resistor, 10.0 OHMS, 1%		MF60C-10R0F
R124	1	Resistor, 5.90K, .5%		MF55C-5901D
R125,131,145	3	Resistor, 475K, 1%		MF55C-4753F
R127	1	Resistor, 1.11K, 0.5%		MF55C-1111D
R132	1	Resistor, 4.12K, 1%		MF55C-4121F
R141	1	Resistor, 10.0K, 1%		MF55C-1002F
R142,143	2	Resistor, 43.2K, 1%		MF55C-4322F
R144	1	Resistor, 390 OHMS, 1/4W		RC07G-391K
R146	1	Resistor, 9.09K, 1%		MF55C-9091F
R191	1	Trim Pot, 10K, 10 Turn	Bournes	3006P-1-103
R195	1	Resistor, 412 OHMS, 0.5%		MF55C-4120D
R196	1	Resistor, 1.05K, 0.5%		MF55C-1051D
R197	1	Resistor, 316 OHMS, 1%		MF55C-3160F
R202,203	2	Resistor, 150 OHMS, 1%		MF55C-1500F
R209A	1	Resistor, 604 OHMS, 0.1%		MF55C-6040B
R209B,R210B	2	Resistor, 90.9K, 1%		MF55D-9092F
R210A	1	Resistor, 301 OHMS, 0.25%		MF55C-3010C
S1	1	Rotary Switch 1 Pole, 4 Pos.	Tempo Instrument Inc.	162143
S3,5	2	Rotary Switch 1 Pole, 5 Pos.	Tempo Instrument Inc.	162145
S4	1	Rotary Switch 1 Pole, 11 Pos.	Tempo Instrument Inc.	162146
S7	1	Rotary Switch 2 Pole, 2 Pos.	Tempo Instrument Inc.	162511

PARTS LIST

"A" BOARD ASS'Y (Cont'd)

SYMBOL NUMBER	QTY	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
TP11	1	Test Point Terminal Yel.	E.F. Johnson	105-2204-201
TP12	1	Test Point Terminal Vio.	E.F. Johnson	105-2207-201
J1	1	Connector	Molex	15-29-60-14
J2,3,4	3	Connector	Molex	15-29-60-08
J5	1	Connector	Molex	10-18-1038
	8	I.C. Socket, 8-Pin	Tempo Instrument Inc.	161428-8
	1	P.C. Board	Tempo Instrument Inc.	162508A
	1	Ty-Wrap	Tempo Instrument Inc.	160240-8

PARTS LIST
"B" BOARD ASSEMBLY

SYMBOL NUMBER	QTY.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
U4-13, U19-21	13	Integrated Circuit, OP-AMP	RCA	CA3140AE
U18	1	Integrated Circuit, OP-AMP	National	LF356N
Q3	1	Transistor, PNP		PN2907A
Q4, 5	2	Transistor, NPN		PN2222A
VR1	1	Voltage Regulator, +12V	National	LM340T-12
VR2	1	Voltage Regulator, -12V	National	LM320T-12
V2	1	Surge Arrestor	CP Clare	CG2-145L
Z1	1	Zener Diode, 6.2V		IN823A
DB1	1	Rectifier Bridge, 1A, 600V	Tempo Instrument Inc.	260711
CR3-6	4	Diode		IN483B
T2	1	Transformer	Tempo Instrument Inc.	260962
T3	1	Transformer 28VCT, 0.42A	Signal	ST5-28
C3, 4, 6, 42	4	Capacitor, 1UF/50V, 20%	Centralab	CZ30C105M
C8-24A, B, 25, 26A, 27, 28, 70C, 72C	24	Capacitor, .01UF/100V, 2%	Electrocube	650B1B103G
C26B	1	Capacitor, .0018UF/100V, 2%	Electrocube	650B1B182G
C29A	1	Capacitor, .001UF/100V, 2%	Electrocube	650B1B102G
C29B	1	Capacitor, 470PF/300V, 2%		CM05FD471GO3
C32, 33	2	Capacitor, 330UF/250VDC	Sprague	80D331P250KD5
C34-36	3	Capacitor, 10UF/25V	Tempo Instrunment Inc.	260689-10-25
C38-40, 43-53	14	Capacitor, .22UF/50V, 20%	Centralab	CZ20C224M
C41	1	Capacitor, .001UF/500V	Sprague	5GA-D10
C70A, 72A	2	Capacitor, 2.0UF/100V, 1%	Electrocube	650B1B205F
C70B, 72B	2	Capacitor, .15UF/100V, 1%	Electrocube	650B1B154F
C73, 74	2	Capacitor, 1500UF/35V	Tempo Instrument, Inc.	260689-1500-35
C75, 76	2	Capacitor, 330UF/35V	Tempo Instrument,Inc.	260689-330-35

PARTS LIST

"B" BOARD ASSEMBLY (Cont'd)

SYMBOL NUMBER	QTY.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
R5-11, 59, 61-63 153, 154, 158, 159, 179, 181, 182, 185, 186, 193	21	Resistor, 100 OHMS, 1/4W		RC07G-101K
R12	1	Resistor, 5.23K, 1%		MF55C-5231F
R13	1	Resistor, 17.8K, 1%		MF55C-1782F
R14	1	Resistor, 11.0K, 1%		MF55C-1102F
R15	1	Resistor, 1.21K, 1%		MF55C-1211F
R16	1	Resistor, 37.4K, 1%		MF55C-3742F
R17	1	Resistor, 113K, 1%		MF55C-1133F
R18	1	Trim Pot, 100 OHMS	Bournes	3386P-101
R19, 27, 36, 43, 60	5	Trim Pot, 5K	Bournes	3386P-502
R20	1	Trim Pot, 50K, 10 Turn	Bournes	3006P-1-503
R21-23, 37-39, 53, 54, 65, 74	10	Resistor, 10K, 1/4W		RC07G-103K
R24	1	Resistor, 31.6K, 1%		MF55C-3162F
R25	1	Resistor, 97.6K, 1%		MF55C-9762F
R26	1	Resistor, 21.5K, 1%		MF55C-2152F
R28, 44	2	Trim Pot, 20K	Bournes	3386P-203
R29	1	Trim Pot, 2K	Bournes	3386P-202
R30	1	Resistor, 17.4K, 1%		MF55C-1742F
R31	1	Resistor, 27.4K, 1%		MF55C-2742F
R32	1	Resistor, 18.7K, 1%		MF55C-1872F
R33	1	Resistor, 402 OHMS, 1%		MF55C-4020F
R34	1	Resistor, 57.6K, 1%		MF55C-5762F
R35, 51	2	Trim Pot, 50 OHMS	Bournes	3386P-500

PARTS LIST

"C" BOARD ASSEMBLY (Cont'd)

SYMBOL NUMBER	QTY.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
U26	1	Shift Register		CD4006BCN
U27	1	Exclusive "or" Gate		CD4070BCN
U28	1	Hex Inverter		CD4069BCN
C77	1	Capacitor, 470 PF/200V	M39014/01-1271	
C78	1	Capacitor, .022MF/100V, Mylar	Intern. Ele	EM220-1A
CR10	1	Diode		IN483B
R212	1	Resistor, 20.0K, 1%, 1/4W		MF55C-2002F
R213	1	Resistor, 267K, 1%, 1/4W		MF55C-2673F
R214	1	Resistor, 100K, 1%, 1/4W		MF55C-1003F
R215	1	Resistor, 1.00K, 1%, 1/4W		MF55C-1001F
	3	I.C. Socket, 14-Pin	Tempo Instrument Inc.	161428-14
	1	P.C. Board	Tempo Instrument Inc.	162724
	2	Fastener	Tempo Instrument Inc.	161422-8
	2	Screw & Washer Assembly	Tempo Instrument Inc.	161087-PH4-1.68

PARTS LIST

"B" BOARD ASS'Y (Cont'd)

SYMBOL NUMBER	QTY.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
R40	1	Resistor, 53.6K, 1%		MF55C-5362F
R41	1	Resistor, 150K, 1%		MF55C-1503F
R42	1	Resistor, 88.7K, 1%		MF55C-8872F
R45,58	2	Trim Pot, 10K	Bournes	3386P-103
R46	1	Resistor, 25.5K, 1%		MF55C-2552F
R47,56	2	Resistor, 8.25K, 1%		MF55C-8251F
R48	1	Resistor, 5.90K, 1%		MF55C-5901F
R49	1	Resistor, 590 OHMS, 1%		MF55C-5900F
R50	1	Resistor, 3.92K, 1%		MF55C-3921F
R52	1	Trim Pot, 500 OHMS	Bournes	3386P-501
R55	1	Resistor, 78.7K, 1%		MF55C-7872F
R57	1	Resistor, 28.0K, 1%		MF55C-2802F
R64	1	Resistor, 2.2K, 1/4W		RC07G-222K
R66,68,70, 72,190	5	Trim Pot, 1K	Bournes	3386P-102
R67,69	2	Resistor, 5.36K, 1%		MF55C-5361F
R71,73	2	Resistor, 15.4K, 1%		MF55C-1542F
R155,168,169	3	Resistor, 475K, 1%		MF55C-4753F
R156,160-165	7	Resistor, 14.7K, 1%		MF55C-1472F
R157,172	2	Resistor, 1.00K, 1%		MF55C-1001F
R166	1	Trim Pot, 10K, 10 Turn	Bournes	3006P-1-103
R167	1	Resistor, 10.0K, 1%		MF55C-1002F
R170	1	Resistor, 4.02K, 1%		MF55C-4021F
R171	1	Trim Pot, 500 OHMS, 10 Turn	Bournes	3006P-1-501
R173	1	Resistor, 680 OHMS, 1/4W		RC07G-681K
R178	1	Resistor, 475 OHMS, 0.5%		MF55C-4750D
R174,175	2	Resistor, 196 OHMS, 1%		MF55C-1960F
R177,183	2	Resistor, 2.00K, 1%		MF55C-2001F

PARTS LIST

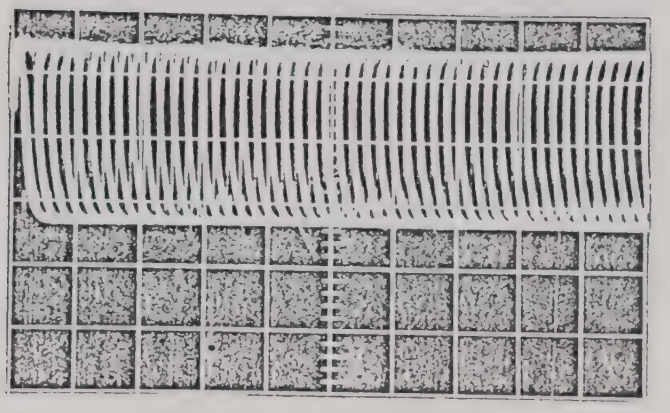
"B" BOARD ASS'Y (Cont'd)

SYMBOL NUMBER	QTY.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
R184	1	Resistor, 1K, 1/4W		RC07G-102K
R187	1	Resistor, 604 OHMS, 1%		MF60D-6040F
R189	1	Resistor, 5.6K, 1/4W		RC07G-562K
R188	1	Resistor, 22K, 1/4W		RC07G-223K
R192	1	Resistor, 12.7K, 1%		MF55C-1272F
R194	1	Resistor, 15K, 1/4W		RC07G-153K
R208A,R211A	2	Resistor, 604 OHMS, 0.1%		MF55C-6040B
R208B,R211B	2	Resistor, 90.9K, 1%		MF55D-9092F
TP1,TP14	2	Test Point Terminal Brn.	E.F. Johnson	105-2201-201
TP2,TP8	2	Test Point Terminal Grey	E.F. Johnson	105-2208-201
TP3,TP21	2	Test Point Terminal Org.	E.F. Johnson	105-2203-201
TP4,TP23	2	Test Point Terminal Yel.	E.F. Johnson	105-2204-201
TP5,TP18	2	Test Point Terminal Grn.	E.F. Johnson	105-2205-201
TP6,TP20	2	Test Point Terminal Blue	E.F. Johnson	105-2206-201
TP7,TP19	2	Test Point Terminal Vio.	E.F. Johnson	105-2207-201
TP9	1	Test Point Terminal Wht.	E.F. Johnson	105-2209-201
TP10,TP13,TP15	3	Test Point Terminal Blk.	E.F. Johnson	105-2200-201
TP17,TP22	2	Test Point Terminal Red	E.F. Johnson	105-2202-201
J6,J8	2	Connector	Tempo Instrument Inc.	162518
J7	1	Connector	Tempo Instrument Inc.	162519
J9	1	Connector	Tempo Instrument Inc.	162520
J10	1	Connector	Tempo Instrument Inc.	162531
	1	P.C. Board	Tempo Instrument Inc.	162509A
	13	I.C. Sockets, 8-Pin	Tempo Instrument Inc.	161428-8
	2	Heat Sink	Thermalloy	6098B

PARTS LIST

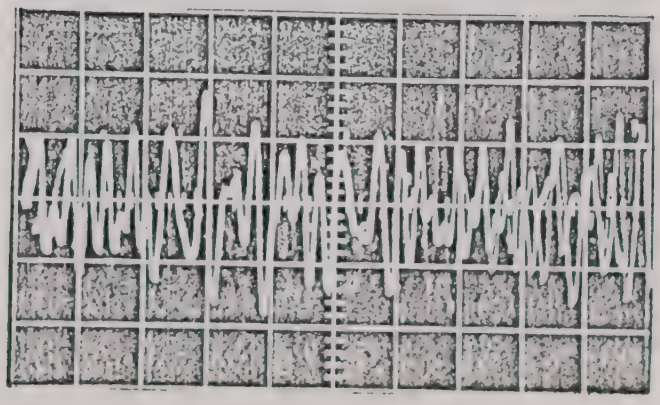
FRONT PANEL AND CHASSIS MOUNTED PARTS

SYMBOL NUMBER	QTY.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
	1	Panel	Tempo Instrument Inc.	162514
M1	1	Meter, 0-1 MA, D.C.	Tempo Instrument Inc.	260963
S2	1	Rotary Switch, 9-Pole, 5-Pos.	Tempo Instrument Inc.	162510
R204,205	2	Resistor, 150 OHMS, 1%		MF55C-1500F
R206A,207A	2	Resistor, 301 OHMS, 0.25%		MF55C-3010C
R206B,207B	2	Resistor, 90.9K, 1%		MF55D-9092F
	(ABOVE SIX RESISTORS USED ON S2)			
E1-3,5-8	7	Binding Post, Black	E.F. Johnson	111-0103-001
E4	1	Grounding Binding Post	H.H. Smith	#208
	1	Spacer (For E4)	Tempo Instrument Inc.	162533
J11-14	4	Phone Jack, 3-Conductor	Switchcraft	MN-112B
	6	Knob	H.Davies	1919
	1	Power Cord, 8 ft. SJO With NEMA 5-15P Plug	Tempo Instrument Inc.	160337-10
	1	Bushing, Strain Relief	Tempo Instrument Inc.	160336-3
S6	1	Switch, Toggle	Carling	2FA63-73
F1,2	2	Fuse, ½A, SLO-BLO	Littelfuse	313.500
	1	Fuse Holder (For F1)	Bussmann	HKP-HH
	1	Fuse Clip (For F2)	Littelfuse	101002
P1,7	2	Connector, 14-PIN	Molex	22-51-1-5-14
	4	Cover (For P1,7)	Molex	15-05-6-14-3
P2,3,4,6,8	5	Connector, 8-PIN	Molex	22-51-1-5-08
	10	Cover (For P2,3,4,6,8)	Molex	15-05-6-08-3
P5,9	2	Connector, 3-PIN	Molex	03-09-1032
P10	1	Connector, 4-PIN (Receptacle)	Molex	03-09-1042
	10	Terminal, Male (For P5,9,10)	Tempo Instrument Inc.	160630
	1	Decal	Tempo Instrument Inc.	162530
	1	Case	Tempo Instrument Inc.	162515



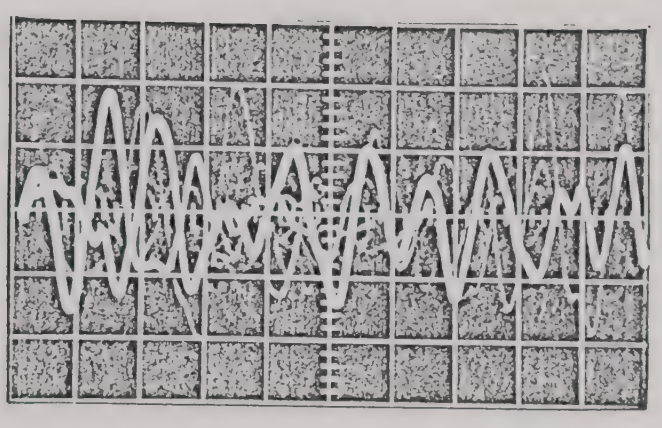
Vert = 2 V/cm, Hor = 50 us/cm

Figure 6-2 Waveform at TP14



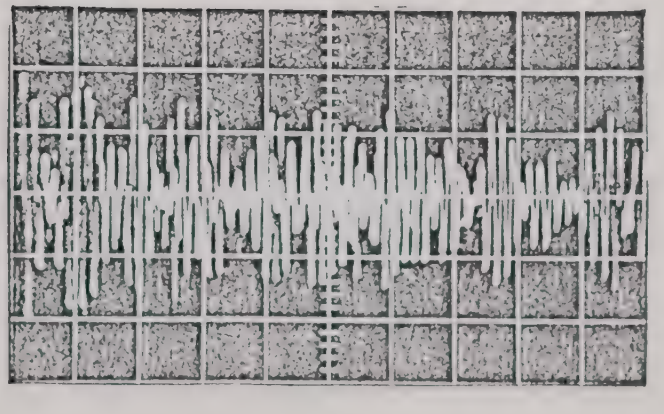
Vert = 2 V/cm, Hor = 2 ms/cm

Figure 6-3 ERL Waveform at Pin 6 of U18



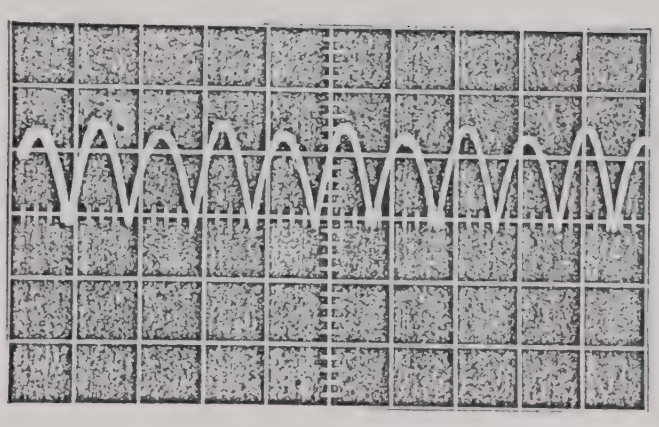
Vert = 2 V/cm, Hor = 2 ms/cm

Figure 6-4 SRL Waveform at Pin 6 of U18



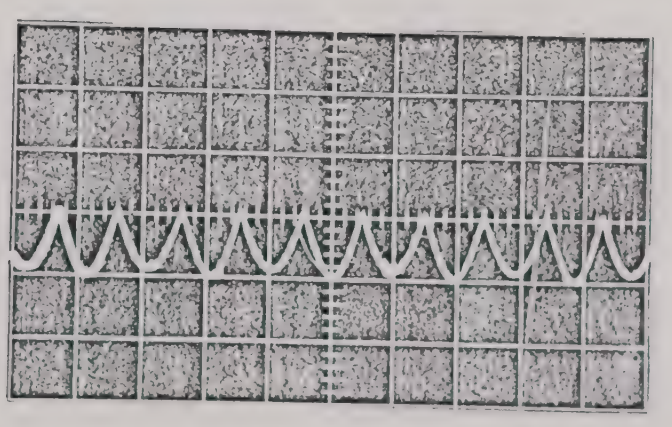
Vert = 2 V/cm, Hor = 2 ms/cm

Figure 6-5 SRL HI Waveform at Pin 6 of U18



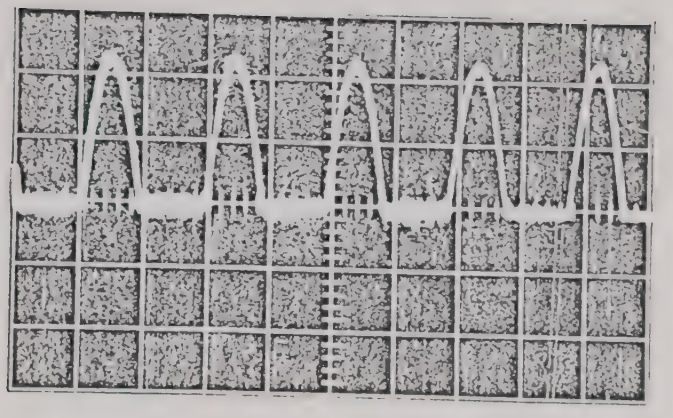
Vert = 1 V/cm, Hor = 0.5 ms/cm

Figure 6-6 Waveform at Pin 6 of U20



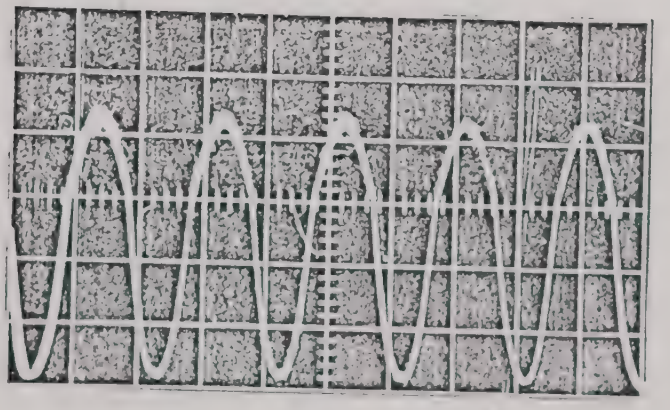
Vert = 1 V/cm, Hor = 0.5 ms/cm

Figure 6-7 Waveform at Pin 6 of U24



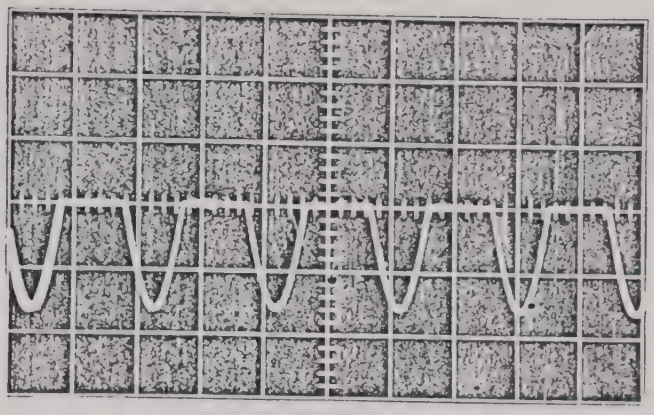
Vert = 0.5 V/cm, Hor = 0.5 ms/cm

Figure 6-8 Waveform at Cathode of CR5



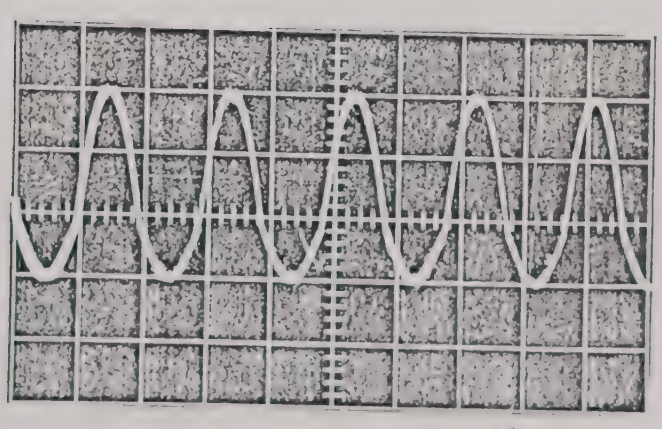
Vert = 0.5 V/cm, Hor = 0.5 ms/cm

Figure 6-9 Waveform at Anode of CR6



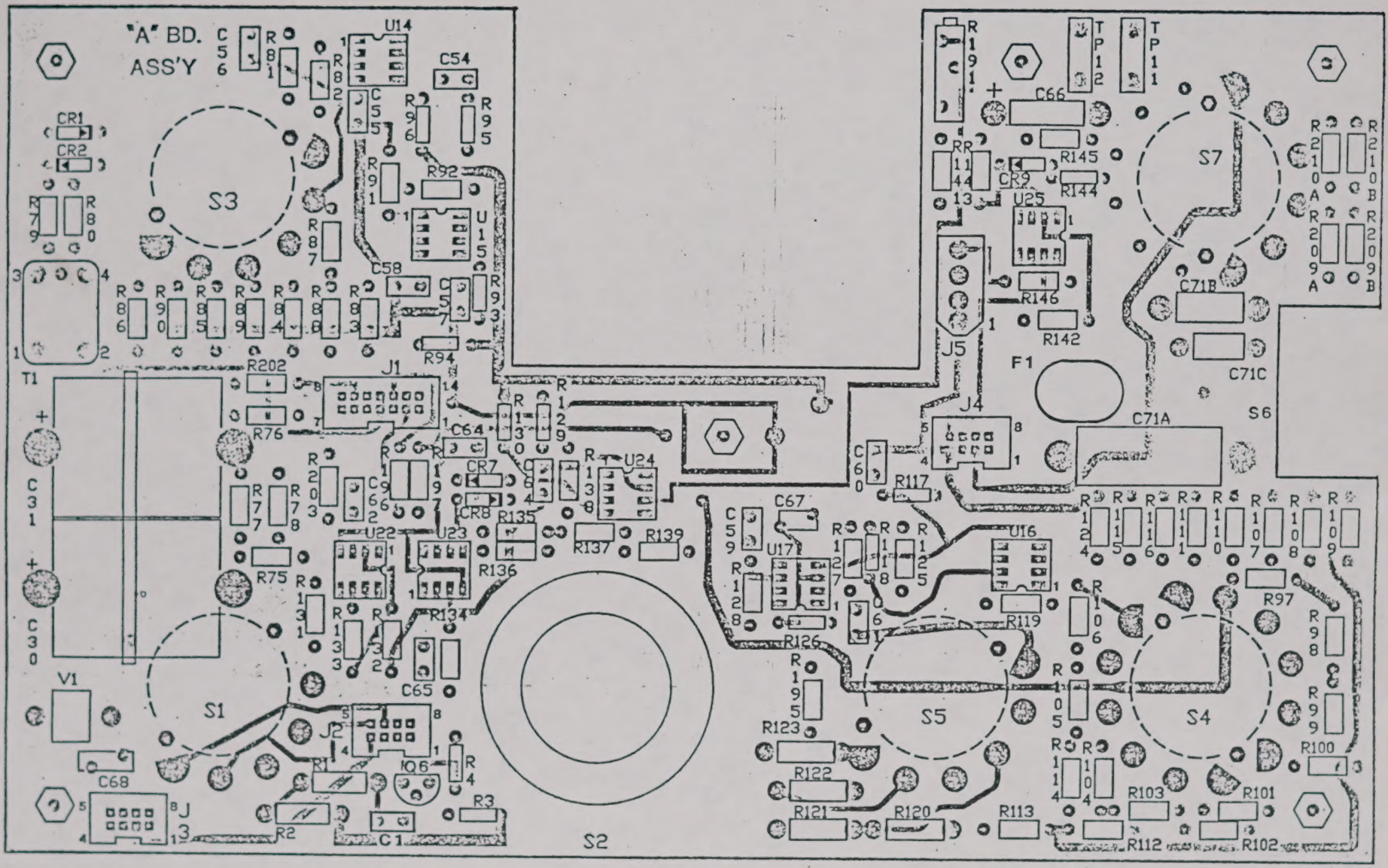
Vert = 0.5 V/cm, Hor = 0.5 ms/cm

Figure 6-10 Waveform at Anode of CR7



Vert = 0.5 V/cm, Hor = 0.5 ms/cm

Figure 6-11 Waveform at Cathode of CR8


"A" BD. ASS'Y
S1
S2
S3
S4
S5
S6
S7
J1
J2
J3
J4
J5
T1
V1
F1
U14
U15
U16
U17
U22
U23
U24
U25
Q6
C54
C58
C64
C65
C66
C67
C68
C71A
C71B
C71C
CR1
CR2
CR7
CR8
CR9
R92
R94
R97
R98
R99
R100
R101
R102
R103
R112
R113
R119
R120
R121
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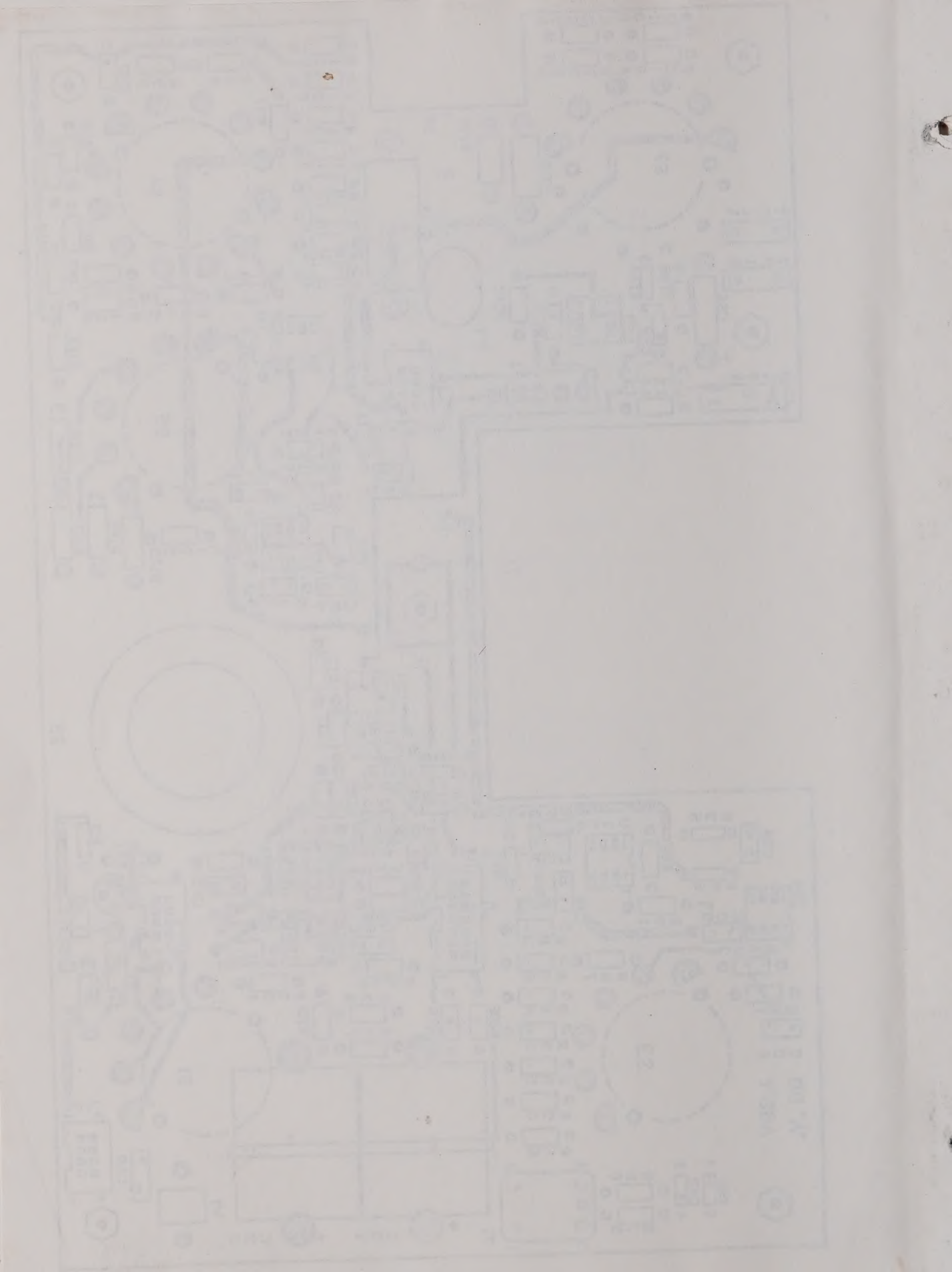
R144
R145
R146
R202
TP11
TP12



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Information
Organizers

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